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ROYAL ASTRONOMICAL SOCIETY,

CONTAINING

PAPERS, ABSTRACTS OF PAPERS, AND

REPORTS OF THE PROCEEDINGS

OF THE SOCIETY

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ROYAL ASTRONOMICAL SOCIETY.

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A. E. Hodgson, Natal Observatory, Durban, Natal ;
H. E. Zufur Jung, G.C.B., Military Minister to His Highness the Nizam, Hyderabad, India ;
Percy Lankester, Highwood House, Kingston Hill, Surrey ;
Thomas Robson, B.A., 14 King's Road, Doncaster ; and
Benjamin Spencer Wolfe, M.A., Victoria College, Jersey,

were balloted for and duly elected Fellows of the Society.

The following candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended :—

Henry John Wolverton Brennand, B.A., M.B., Ch.M., F.C.S., Government Statistician's Department, and 203 Macquarie Street, Sydney, New South Wales (proposed by G. H. Knibbs) ;

Albert Edward Garrett, F.R.G.S., Science Lecturer, 127 Lothair Road, Finsbury Park, N. (proposed by E. A. Reeves) ;

Joseph M. Harvey, 77 Clousdale Road, Upper Tooting, S.W. (proposed by Sir R. S. Ball) ;

John George Hatchard, Mechanical Engineer, C.S.A. Railway Works, Pretoria, Transvaal, South Africa (proposed by A. Fowler) ;

The Rev. Gustavo Heredia, S.J., Stonyhurst College Observatory, Blackburn, Lancashire (proposed by Rev. W. Sidgreaves) ;

Herbert Kitchin, Electrical Contractor, Marshall Square, Johannesburg, Transvaal, South Africa (proposed by R. T. A. Innes) ;

George Aimer Russell, M.A., B.Sc., 29 Glebe Road, Kilmarnock, Scotland (proposed by R. Copeland) ; and

Frank Herbert Shaw, Burlington House, Huddersfield (proposed by T. K. Mellor).

One hundred and eighty-eight presents were announced as having been received since the last meeting, including, amongst others :—

J. C. Clancey, Aid to Land-surveying, 2nd edition, and Calculating Tables, part 1, 4th edition ; Gavin J. Burns, chart showing proper motions of 2,500 stars ; H. Fritsche, Atlas des Erdmagnetismus, presented by the authors ; Galileo, Opere, Edizio Nazionale, vol. 13, presented by the Italian Government ; Galileo, the private life of ; Mary Somerville, personal recollections of, by her daughter, presented by Mrs. McCance ; J. F. Schroeter, Eigenbewegung von Sternen in der Zone $+65°$ zu $+70°$, presented by the Christiania Observatory ; A. R. Wallace, Man's Place in the Universe, presented by the author ; Paris, Congrès Astrophotographique International ; Catalogue photographique, Tome I. ; Carte photographique (18 charts), presented by the French Government ; Potsdam Observatory, Photographische Himmelskarte, Band 3, presented by the Observatory.

Photographic portrait of Sir J. F. W. Herschel, presented by Sir W. Herschel, Bart. ; Spectroheliograph of the Sun, presented by the Solar Physics Observatory ; photographs of the spectrum of lightning, presented by Dr. Lockyer ; Negatives of the Sun, showing great sun-spots, presented by Mr. Newbegin ; photographs (negatives) showing absorption of the light of a star by comet Borrelly, presented by Dr. Max Wolf.

On the Systematic Proper Motions of Bright Stars relatively to Faint Stars in the Oxford Zones ($+25°$ *to* $+31°$). By H. H. Turner, D.Sc., F.R.S, Savilian Professor.

1. In *Monthly Notices*, vol. lxiii. pp. 56–71, a preliminary discussion is given of the systematic proper motions in R.A. of bright stars relatively to faint, as determined from the Oxford photographs about 27° declination. The systematic proper motions were deduced by an *indirect* process as follows: Comparison of measures on plates taken at Oxford about 1894, with Cambridge meridian observations made about 1879, gives the sum of two quantities—viz. proper motion for fifteen years + Cambridge magnitude equation. Again, comparison of measures on plates taken at Oxford about 1899 with the Cambridge meridian observations gives

proper motion for 20 years + Cambridge magnitude equation.

Assuming the magnitude equation to be the same in both cases, we get by subtraction the systematic proper motions for five years.

2. Such a process has defects which are only too obvious and the results can only be put forward provisionally. I hope that before long we may undertake a direct determination of the relative proper motions in at least a part of our zone. We hope to finish the measures of our 1,180 plates prescribed in the programme before the end of the present year. When this is done it will be about ten years since the first of them was taken. We might therefore with advantage repeat the early plates, and measure the relative star places again after this interval of ten years. This proceeding could be restricted, in the first instance, to the odd zones $+25°$, $+27°$, $+29°$, $+31°$, so that we need only repeat four-sevenths of the work, and would be a general check on the previous measures, besides furnishing relative proper motions for ten years. As a general check it would not be much more laborious than the comparison of the measures on overlapping plates, for the numerical work necessary for this comparison, though straightforward, is considerable in amount. (See *Monthly Notices*, vol. lxi. p. 422.) As determining proper motions it would give greater completeness to the survey. The following remark is made by Herr E. Anding in reviewing Professor Newcomb's "Stars: a Study of the Universe" (*V. J. S. Ast. Ges.* 37. Jahr, iv. Heft, p. 333):—

"Schon S. 14 heisst es, der Bau des Universums sei das grösste Problem, das sich der Menschengeist jemals gestellt habe. Solchen Aeusserungen begegnet man nicht selten in der Literatur, häufiger in der letzten Zeit als früher. Doch hat Ref.

noch niemals Gründe gefunden, warum diese $3n$ Anfangsconstanten wichtiger sein sollen, als die $3n$ Geschwindigkeiten. Nicht einmal ein heuristisches Moment lässt sich geltend machen: denn man wird die $3n$ Coordinaten gar nicht bestimmen können, ohne dass man zugleich die Geschwindigkeiten einführt."

To determine the places of a number of stars at any epoch is, after all, only half an investigation; we must also determine their proper motions, at least approximately, if we require their positions at other epochs.

3. Meanwhile it seems desirable to complete the former *indirect* investigation by treating the declinations in the same way as the R.A.'s, as promised in § 32 of the paper already quoted; and this is the object of the present paper. I shall first give for the y coordinate tables precisely similar to those formerly given for the x coordinate.

4. It seems unnecessary to repeat Tables I. and II., which will be found on p. 58 of vol. lxiii. Table I. gives the mean date of the groups and the number of plates in each. Briefly, there are about sixty "early" plates and sixty "late" plates in each of the zones $+26°$, $+27°$, $+29°$; and the mean difference of date is about five years. Table II. shows the numbers of stars of various magnitudes on these plates.

5. In Table III. we have what was called in the earlier paper the "raw material" for the discussion. The letters E and L are used to denote "early" and "late" plates.

TABLE III. (y.)

Mean y Residual (Oxford – Cambridge) for each group in units of 0″·3.

Zone +26°.

Octant of R.A. h h	Mag. 6·0. E.	L.	Mag. 7·5. E.	L.	Mag. 8·5. E.	L.	Mag. 9·0. E.	L.	Mag. 9·4. E.	L.
0– 3	– 5	– 4	–32	–17	–10	– 6	0	+ 4	+15	+ 7
3– 6	– 9	+ 3	–30	– 9	+ 3	– 4	– 1	+ 4	+ 2	– 1
6– 9	–53	+ 3	– 5	– 7	+ 2	– 1	0	– 1	+ 6	+ 5
9–12	–27	–17	–30	–19	+ 1	+ 8	– 4	– 9	+ 7	+ 3
12–15	– 7	– 3	–12	– 1	– 4	– 6	– 1	+ 5	+ 6	– 1
15–18	–40	0	+30	–16	+ 2	– 1	+13	0	– 8	+ 5
18–21	– 4	+ 4	– 4	– 5	0	– 2	– 1	– 3	+ 1	– 1
21–24	–13	–25	–22	– 7	– 4	–16	+ 2	+15	+ 6	+ 1
Mean	–19·8	– 4·9	13·1	–10·1	– 1·3	– 3·5	+ 1·0	+ 1·9	+ 4·4	+ 2·3

Zone +27°.

Octant of R.A. h h	Mag. 6·0. E.	L.	Mag. 7·5. E.	L.	Mag. 8·5. E.	L.	Mag. 9·0. E.	L.	Mag 9·4 E.	L.
0– 3	*(−33)	−15	*(−25)	+ 7	*(− 7)	− 5	*(0)	+ 7	*(+13)	+12
3– 6	−12	+ 5	−13	−11	+ 1	− 3	+ 3	0	+ 2	+ 6
6– 9	−32	−33	− 9	− 8	0	+ 1	+ 2	+ 3	+ 6	+12
9–12	−40	−15	0	−11	+ 5	− 2	+18	+ 1	+10	+ 2
12–15	− 9	−20	− 8	− 4	0	− 6	− 2	0	+10	+13
15–18	−13	+ 8	− 3	− 7	0	− 3	+ 4	+ 2	+ 7	+ 3
18–21	+13	−11	0	− 5	− 5	− 4	+ 2	− 3	0	0
21–24	− 7	+ 3	− 9	−13	0	− 7	− 1	+ 4	+11	+ 4
Mean	−16·6	− 9·8	− 8·4	− 6·5	− 0·8	− 3·6	+ 3·3	+ 1·8	+7·4	+ 6·5

Zone +29°.

Octant of R.A. h h	Mag. 6·0. E.	L.	Mag. 7·5. E.	L.	Mag. 8·5. E.	L.	Mag. 9·0. E.	L.	Mag. 9·4. E.	L.
0– 3	−60	−43	−19	− 2	− 4	− 4	+ 1	+ 3	+11	+10
3– 6	−12	− 9	− 6	− 2	− 2	− 9	+ 4	− 4	+ 5	+12
6– 9	− 6	−55	− 4	− 7	− 7	− 6	− 1	0	+16	+ 7
9–12	− 5	+ 5	− 7	+ 5	+ 3	+ 2	− 2	+ 1	+11	+ 2
12–15	− 1	−37	− 3	−10	− 7	− 2	− 1	− 7	+ 8	+43
15–18	+ 5	+19	+ 6	−25	− 5	− 3	0	+ 1	+ 7	+ 2
18–21	+ 1	+20	− 1	− 9	− 5	−15	− 3	− 1	+ 2	− 2
21–24	−18	−10	− 9	−25	− 4	− 9	− 3	− 8	+ 6	+ 7
Mean	−12·0	−13·8	− 5·4	− 9·4	− 3·9	− 5·8	− 0·6	− 1·9	+ 8·3	+10·1

6. To follow the course of the previous paper we first set down as a preliminary result the differences between the means of the eight octants as they stand. These do not give us comparable proper motions, because the intervals, although all approximately five years, differ sensibly among themselves; but we get a sufficient test of the homogeneity of our material.

TABLE IV. (*y*.)

Approximate Mean P.M.'s in Decl. for five years in units of 0″·03.

	Magnitude. 6·0.	7·5.	8·5.	9·0.	9·4.
Decl. +26°	+14·9	+3·0	−2·2	+0·9	−2·1
„ +27	+ 6·8	+1·9	−2·8	−1·5	−0·9
„ +29	− 1·8	−4·0	−1·9	−1·3	+1·8
Mean	+ 6·6	+0·3	−2·3	−0·6	−0·4

* The mean of results for zones +26° and +29° has been substituted.

7. These numbers differ in a marked manner from the corresponding numbers for R.A., in which there was a distinct progression. It seems worth repeating the former table for comparison :

TABLE IV. (*x*.)

Approximate Mean P.M.'s in R.A. for five years in units of 0''·03 *or* 0ˢ·00225.

	Magnitude.				
	6·0	7·5·	8·5·	9·0.	9·4·
Decl. + 26°	− 18·6	− 8·7	+ 1·5	− 0·3	+ 2·6
,, + 27°	− 6·9	− 7·2	+ 0·2	+ 0·9	+ 2·5
,, + 29°	− 15·1	− 4·8	− 3·5	− 1·1	+ 2·4
Mean	− 13·5	− 6·9	− 0·6	− 0·2	+ 2·5

In Table IV. (*x*) there was a sufficient accordance between the numbers for the three years to encourage us to believe that we were dealing with some systematic phenomenon ; but this accordance is not reproduced in Table IV. (*y*.) Indeed, the results for zone + 26° and zone + 29° are almost precisely at variance ; while zone + 27° falls in between the two, as is shown by its agreement with the means. We are driven to infer that the systematic proper motions, in declination at any rate, are very small compared with those which do not follow any systematic law of drift ; or possibly that the accidental errors of measurement are larger than we should naturally expect. And in the light of these new results we naturally regard the apparent accordance of Table IV. (*x*) with more caution.

8. We proceed nevertheless to combine the three zones. We may still hope to diminish the "accidental errors" by so doing, though the whole work is put on a more tentative basis. Table VI. (*y*) has been formed in the same way as Table VI. of the former paper. We may first repeat Table V., as it is required for the formation of Table VII. It shows the number of plates for each octant of R.A. and the mean interval in years.

TABLE

Mean Results

(The unit

Octant of R.A. h h	Interval in Years.	6·0 E.	6·0 L.	6·0 L—E.	7·5 E.	7·5 L.	7·5 L—E.
0 − 3	5·2	− 41·7	− 27·3	+ 14·4	− 23·3	− 5·6	+ 17·7
3 − 6	5·2	− 11·3	− 0·8	+ 10·5	− 15·2	− 7·1	+ 8·1
6 − 9	4·9	− 27·6	− 26·8	+ 0·8	− 6·8	− 7·3	− 0·5
9 − 12	5·3	− 16·2	− 8·6	+ 7·6	− 15·3	− 7·4	+ 7·9
12 − 15	4·5	− 3·6	− 13·3	− 9·7	− 5·9	− 3·1	+ 2·8
15 − 18	4·6	− 4·5	+ 7·8	+ 12·3	+ 6·2	− 14·2	− 20·4
18 − 21	4·1	+ 1·4	+ 3·6	+ 2·2	− 1·9	− 5·9	− 4·0
21 − 24	4·0	− 14·1	− 1·5	+ 12·6	− 13·1	− 14·5	− 1·4

TABLE V.

Octant of R.A.	0^h–3^h	3^h–6^h	6^h–9^h	9^h–12^h	12^h–15^h	15^h–18^h	18^h–21^h	21^h–24^h
Num. E plates	12	23	29	13	29	19	33	38
Num. L. plates	16	27	24	38	23	35	23	12
Mean interval	5·2	5·2	4·9	5·3	4·5	4·6	4·1	4·0

TABLE VII. (*y*.)

Deduced Relative Motions in each Octant.

(The unit is 0″·03.)

Octant. h h	Mag. 6·0.	Mag. 7·5.	Mag. 8·5.	Mag. 9·0.	Mag. 9·4.	Gradients. Bright Stars.	Gradients. Mean.	Gradients. Faint Stars.
0 – 3	+2·8	+3·4	+0·2	+0·6	−0·6	−0·4	+1·4	+0·9
3 – 6	+2·0	+1·6	−1·2	−0·5	+0·7	+0·3	+1·0	−2·1
6 – 9	+0·2	−0·1	−0·1	0·0	−0·3	+0·2	+0·1	+0·2
9 – 12	+1·4	+1·5	−0·1	0·0	−1·4	−0·1	+0·9	+1·4
12 – 15	−2·2	+0·6	−0·1	+0·6	+0·2	−1·9	−0·5	−0·3
15 – 18	+2·7	−4·4	+0·1	−0·3	−0·4	+4·7	−0·3	+0·6
18 – 21	+0·5	−1·0	−0·5	−0·3	−0·6	+1·0	+0·1	+0·1
21 – 24	+3·2	−0·4	−1·2	+1·0	−0·7	+2·4	+0·8	−0·6
Mean	+1·33	+0·15	−0·36	+0·14	−0·39	+0·78	+0·44	+0·03

9. The differences between early and late plates have then been divided by the mean intervals shown in Table V., so as to get the annual P.M.'s, shown in Table VII., still expressed in units of 0″·03. The "gradients" in the last three columns have been formed as follows: Subtracting from the mean of the results for magnitudes 6·0 and 7·5 the mean of the three results for 8·5, 9·0, and 9·4, and dividing the difference by 2·2 (the difference of the mean magnitudes), we get the mean relative P.M. for one magnitude, which is called the mean gradient. But

VI. (*y*.)

for all Zones.

is 0″·03.)

8·5 E.	8·5 L.	8·5 L—E.	9·0 E	9·0 L.	9·0 L—E.	9·4 E.	9·4 L.	9·4 L—E.
−6·0	−4·8	+1·2	+0·7	+3·8	+3·1	+12·3	+9·3	−3·0
+0·8	−5·5	−6·3	+2·3	−0·3	−2·6	+2·7	+6·1	+3·4
−1·8	−2·1	−0·3	+0·7	+0·5	−0·2	+9·1	+7·7	−1·4
+2·4	+1·7	−0·7	−1·2	−1·4	−0·2	+9·4	+2·2	−7·2
−5·3	−5·7	−0·4	−1·1	+1·8	+2·9	+7·8	+8·9	+1·1
−2·9	−2·3	+0·6	+2·4	+1·1	−1·3	+5·4	+3·5	−1·9
−3·2	−5·3	−2·1	−1·4	−2·6	−1·2	+1·3	−1·0	−2·3
−3·2	−8·1	−4·9	−1·0	+2·9	+3·9	+7·1	+4·3	−2·8

as the gradient may not be uniform two other columns have been formed, that for "bright" stars by comparing the results for 6·0 and 7·5 and dividing by 1·5, and that for "faint" stars by comparing 8·5 and 9·4 and dividing by 0·9. The accidental errors of these columns are, of course, much larger than that for the mean.

10. The question raised in the previous paper was : How far can these relative proper motions of bright and faint stars be referred to the Sun's motion through space? The expressions for the parallactic motion are

$$\mu^{\alpha} = +(\mathrm{V}\cos\mathrm{D}\sec\delta)\times\varpi\times\sin(\alpha-\mathrm{A})$$
$$\mu_{\delta} = +(\mathrm{V}\cos\mathrm{D}\sec\delta)\times\varpi\times\mathrm{K},$$

where

$$\mathrm{K} = \sin\delta\cos\delta\cos(\alpha-\mathrm{A})-\cos^2\delta\tan\mathrm{D},$$

V being the Sun's velocity, A and D the R.A. and Decl. of the point towards which the Sun is moving, and ϖ the annual parallax of a star whose R.A. and Decl. are α and δ.

11. Assuming V cos D sec δ to be constant for the results now under discussion, the values of $(\mathrm{V}\cos\mathrm{D}\sec\delta)\times\varpi$ were found in the previous paper (p. 68) by dividing μ_{α} by $\sin(\alpha-\mathrm{A})$. They can now be found independently from the P.M.'s in declination by dividing μ_{δ} by K, and a comparison of the results will tell us how far we are right in ascribing these relative P.M.'s to the Sun's motion in space. The comparison is shown in Table VIII.

TABLE VIII.

Octant. h h	μ_{α}	$\sin(\alpha-\mathrm{A})$.	$\mu_{\alpha}/\sin\alpha-\mathrm{A}$.	μ_{δ}.	K.	μ_{δ}/K.
0– 3	−2·1	+·9	−2·3	+1·4	−·6	−2·3
3– 6	−0·1	+·4	−0·2	+1·0	−·8	−1·3
6– 9	−0·8	−·4	+2·0	+0·1	−·8	−0·1
9–12	−0·1	−·9	+0·1	+0·9	−·6	−1·5
12–15	−0·7	−·9	+0·8	−0·5	−·3	+1·7
15–18	+0·5	−·4	−1·1	−0·3	(−·1)	(+3·0)
18–21	−0·3*	+·4	−0·8*	+0·1	(−·1)	(−1·0)
21–24	−0·8	+·9	−0·9	+0·8	−·3	−2·7

12. The values of $\sin(\alpha-\mathrm{A})$ and K are only approximate, and for the groups $15^{\mathrm{h}}-18^{\mathrm{h}}$ and $18^{\mathrm{h}}-21^{\mathrm{h}}$ the value of K cannot be trusted as a divisor. (An accurate value might just possibly have a small positive sign.) If we exclude these groups and arrange the others according to the value of $\mu_{\alpha}/\sin(\alpha-\mathrm{A})$ we get the following quantities, which should agree :—

* There is unfortunately a slight error in Table VII. of the previous paper, which is here corrected. The consequent errata are given at end of this paper.

Octant.	0^h-8^h	21^h-24^h	3^h-6^h	9^h-12^h	12^h-15^h	6^h-9^h
$\mu_\alpha/\sin(\alpha-A)$	−2·3	−0·9	−0·2	+0·1	+0·8	+2·0
μ_δ/K ...	−2·3	−2·7	−1·3	−1·5	+1·7	−0·1

13. Considering the large accidental error which obviously affects the results, the accordance is not unsatisfactory. If we accept it as showing that we are getting some indication, however rough, of the relative parallaxes of bright and faint stars in the different octants, then we may combine the two sets of results to improve this determination. Let us change the sign of μ_α when $\sin(\alpha-A)$ is negative, and of μ_δ when K is negative, and add the two together, dividing by the numerical sum of the factors, as in Table IX. There is now less reason for excluding the groups bracketed.

TABLE IX.

Octant. h h	$\pm\mu_\alpha\pm\mu_\delta$.	$\pm\sin(\alpha-A)\pm K$.	Ratio $=\varpi V \cos D \sec\delta$.	Galactic Latitude.
				°
0− 3	−3·5	1·5	−2·3	−34
3− 6	−1 1	1·2	−0·9	−13
6− 9	+0·7	1·2	+0·6	+22
9−12	−0·8	1·5	−0·5	+61
12−15	+1·2	1·2	+1·0	+80
15−18	−0·2	0·5	−0·4	+40
18−21	−0·4	0·5	−0·8	+ 2
21−24	−1·6	1·2	−1·3	−25

14. The approximate galactic latitude of the group has been inserted, as in Table XI. of the former paper (*Monthly Notices*, lxiii. p. 68). If we arrange the results simply according to latitude we get the following series, the results of the former paper, obtained from R.A. alone, being added for comparison :—

Deduced Value of ϖ V *cos* D *sec* δ *for different Galactic Latitudes.*

Gal. Lat.	+2°	−13°	+22°	−25°	−34°	+40°	+61°	+80°
R.A. and Decl.	−0·8	−0·9	+0·6	−1·3	−2·3	−0·4	−0·5	+1·0
R.A. alone	−0·8	−0·2	+2·0	−0·9	−2·3	−1·1	+0·1	+0·8

15. It does not, therefore, seem impossible that there may be some reversal, over a limited range of magnitudes, of the law that parallax and brightness diminish together, which is specially marked at about 35° from the galaxy. At any rate a case has been made out for further inquiry.

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16. We will now consider the results obtained from another point of view, which depends, however, on an assumption which may not be true.

Can we assume that the Cambridge magnitude equation is the same for all R.A.'s?

This assumption has usually been made, but it must at any rate be carefully examined, and recent work (see *Obs.* xxvi. p. 210) seems to show that it is sometimes, perhaps always, erroneous. But by adopting it for an independent investigation of the quantities under discussion we shall throw some light on the validity of the assumption itself. The use to be made of it will now be stated.

17. Consider for simplicity two stars only, a bright B and a faint F. About 1879 these two stars were observed at Cambridge, and taking B as correct, the observed R.A. of F was too large, by M, say. About 1894 these stars were photographed at Oxford. F had meanwhile been moving with reference to B and had increased its relative R.A. by 15P, say, where P is the relative P.M. per year. Hence we should find, on comparing the Oxford photograph with the Cambridge places,

$$M_1 = M + 15P,$$

as the Cambridge magnitude equation, instead of M, as before. Again, other photographs were taken at Oxford about 1899. Had they been of the same actual stars we could have compared them directly with those of 1894, and avoided using the Cambridge observations as an intermediary ; but they were of different regions, and we thus find for the Cambridge magnitude equation

$$M_2 = M' + 20P'.$$

Now in what precedes it has been assumed that in the same part of the sky (*i.e.* in each separate octant) $M = M'$ and $P = P'$, for the mean of a large number of stars. The former assumption is probably correct ; but the latter is more doubtful, as we noticed in § 7 of this paper. Still we have hitherto been working on this assumption ; and from it we have deduced, by subtracting the above equations,

$$5P = M_2 - M_1,$$

and if we substitute this value of P in either of the above equations we get

$$M = 4M_1 - 3M_2.$$

18. Now, if we could assume that the value of M should be the same for all R.A.'s we could get for it by combining all the octants a much better value, M_0, than the value deducible from a single octant alone. Using this mean value we could then find P for each octant from the equations

$$35P = (M_1 + M_2) - 2M_0 \quad \ldots \quad \ldots \quad (a)$$

and a comparison of the results with those already found from the equations

$$5P = M_2 - M_1 \quad \ldots \quad \ldots \quad \ldots \quad (b)$$

would give a valuable check upon them. The same would, of course, hold good if we in any way knew the value of M_o in equation (*a*) *independently* of the present observations. But to substitute the value determined from the present observations, viz.

$$M = 4M_1 - 3M_2 \quad \ldots \quad \ldots \quad \ldots \quad (c)$$

simply reduces equation (*a*) to identity with (*b*).

19. Hence we cannot get any value for the P.M.'s independent of that already found unless we can find some value for M different from that directly furnished by equation (*c*) ; though if M may be regarded as the same for all octants, its mean value, derived from the mean of eight equations like (*c*), would practically satisfy requirements. Let us in the first place see whether it seems likely that M *is* constant in value ; and first consider the results for the *y* coordinate, collected in the present paper.

20. Recurring to Table VI. (*y*), the letters E and L correspond to what we have called M_1 and M_2. Now from (*c*)

$$M = M_2 - 4(M_2 - M_1)$$
$$= L - 4(L - E).$$

We can thus form M very readily by subtracting four times the column (L−E) from the column preceding it. The factor four should not be absolutely constant : it is really the ratio of the interval between the Cambridge observations and the Oxford L plates to the interval between L and E. The former may be taken as 20 ; the latter is given in Table VI. The results are shown in Table X. (*y*) for each magnitude ; and in the column "Mean Gradient" a result is found, as before, by subtracting the mean of the last three columns from the mean for 6·0 and 7·5, and dividing by 2·2.

Table X. (*y*.)

Values of M *deduced from Table VI.* (*y*) *in units of* 0″·03.

Octant of R.A. h h	Factor.	6·0	7·5	8·5	9·0	9·4	Mean Gradient.
0 − 3	3·8	−82·0	−72·9	− 9·4	− 8·0	+20·7	−35·7
3 − 6	3·8	−40·7	−37·9	+18·4	+ 9·6	− 6·8	−21·0
6 − 9	4·1	−30·1	− 5·2	0·9	+ 1·3	+13·4	−10·0
9 − 12	3·8	−37·5	−37·4	+ 4·4	− 0·6	+29·6	−22·0
12 − 15	4·4	+29·4	−15·4	− 4·0	−11·0	+ 4·1	+ 4·8
15 − 18	4·4	−46·3	+75·6	− 4·9	+ 6·8	+11·9	+ 4·5
18 − 21	4·9	− 7·2	+13·7	+ 5·0	+ 3·3	+10·3	− 1·3
21 − 24	5·0	−64·5	− 7·5	+16·4	−16·6	+18·3	−19·1
Mean	4·3	−34·9	−10·9	+ 3·1	− 1·9	+12·7	−12·5

21. Now a mere glance at this table is sufficient to show that the values of M indicated are far too large and irregular. Take, for instance, the column headed "Mean Gradient," which represents the mean magnitude equation *per magnitude* in declination at the epoch 1875·0, if the systematic P.M.'s we are dealing with are treated as accurate and carried back twenty years; and its value in the first octant is found to be $-35{\cdot}7 \times 0''{\cdot}03 = -1''{\cdot}07$, while in the 5th and 6th it is about $+0''{\cdot}14$. This range is quite inadmissible. Even the mean value $-12{\cdot}5$ or $-0''{\cdot}37$ is too large, being more than double the quantity found, for instance, by Auwers (*Ast. Nach.* No. 3844, p. 72).

22. It would, therefore, appear that our results do not truly represent *systematic* proper motions. Either the individual proper motions are too large compared with any systematic drift to satisfactorily nullify one another in our means or there is some unknown source of accidental error. It may be that the magnitude equation varies with R.A., but it certainly does not vary as much as would be indicated by Table X. (*y*), and we have no independent determination of its variation.

23. But it is still of interest to find what systematic P.M.'s would be given by the assumption that M_o was the same for all R.A.'s, from the equation (*a*) of § 18. In this method we practically cease to differentiate E and L plates. We take the mean of both, and find how much M has strayed from its original value M_o in each octant owing to systematic P.M. during the interval of about 17·5 years between the Cambridge observations and the Oxford plates.

24. We must, however, decide what value to use for M_o. In Auwers's paper above referred to (*Ast. Nach.* No. 3844, p. 72) the values of M_o referred to magnitude 9·0 as zero, and expressed in our units of $0''{\cdot}03$, would be

TABLE XI. (*y*.)

Values of M_o.

	6·0	7·5	8·5	9·0	9·4	Mean Grad.
Auwers	−12·3	−9·7	−4·0	0·0	+ 3·2	− 4·9
Table X. (*y*) (Means)	−33·0	−9·0	+5·0	0·0	+14·6	−12·5

In order to render the new results as much as possible independent of the old we will adopt the results given by Auwers as they stand, and find the values of P for each octant from equation (*a*) of § 18, where for M_1 and M_2 we take simply the E and L of Table VI. (*y*.) The results are given in Table XII. (*y*), and the results of Table VII. (*y*) are added for comparison.

TABLE XII. (*y*.)

Systematic P.M.'s in Declination deduced from the 17½ years' interval between Cambridge Meridian Observations and Oxford Plates, assuming Auwers's determination of the Magnitude Equation to hold good in all R.A.'s.

Octant of R.A.	Mag. 6·0. New Det.	Mag. 6·0. Old (Table VII.)	Mag. 7·5. New	Mag. 7·5. Old	Mag. 8·5. New	Mag. 8·5. Old	Mag. 9·0. New	Mag. 9·0. Old	Mag 9·4. New	Mag 9·4. Old	Mean Gradient. New Det.	Mean Gradient. Old (Table VII.)
h h												
0– 3	−1·3	+2·8	−0·3	+3·4	−0·1	+0·2	+0·1	+0·6	+0·4	−0·6	−0·4	+1·4
3– 6	+0·4	+2·0	−0·1	+1·6	+0·1	−1·2	+0·1	−0·5	+0·1	+0·7	0·0	+1·0
6– 9	−0·9	+0·2	+0·2	−0·1	+0·1	−0·1	0·0	0·0	+0·3	−0·3	−0·2	+0·1
9–12	0·0	+1·4	−0·1	+1·5	+0·3	−0·1	−0·1	0·0	+0·2	−1·4	−0·1	+0·9
12–15	+0·2	−2·2	+0·3	+0·6	−0·1	−0·1	0·0	+0·6	+0·3	+0·2	+0·1	−0·5
15–18	+0·8	+2·7	+0·3	−4·4	+0·1	+0·1	+0·1	−0·3	+0·1	−0·4	+0·2	−0·3
18–21	+0·8	+0·5	+0·3	−1·0	0·0	−0·5	−0·1	−0·3	−0·2	−0·6	+0·3	+0·1
21–24	+0·3	+3·2	−0·2	−0·4	−0·1	−1·2	+0·1	+1·0	+0·1	−0·7	0·0	+0·8

25. The last pair of columns alone is sufficient to show that there is no correspondence between the new determination of systematic proper motions and those of Table VII. : either one or the other set is quite untrustworthy. We can improve the accordance a little by assuming a different value for the original magnitude equation of the Cambridge observations, which means simply adding a constant to the column headed "New Determination;" but the improvement is not sufficient to give at length.

26. Before proceeding to examine what values the new determination would give to the relative parallax of bright and faint stars, as in Table VIII., we will form the corresponding results for R.A. on the new plan. The following tables, X. (*x*), XI. (*x*), and XII. (*x*), correspond precisely to those given above for (*y*), and it is perhaps unnecessary to repeat the explanations. They are derived from Table VI. on p. 62 of *Monthly Notices*, vol. lxiii., in exactly the same way as the tables for (*y*) are derived from Table VI. (*y*) of the present paper.

TABLE X. (*x*).

Values of M *deduced from Table VI. ("Monthly Notices," vol. lxiii. p. 62) in units of* 0″·03.

Octant of R.A.	Factor.	6·0	7·5	8·5	9·0	9·4	Mean Gradient.
h h							
0– 3	3·8	+165·7	+146·7	+57·1	+34·8	−45·0	+63·9
3– 6	3·8	+ 25·5	+ 13·0	−14·1	−11·3	−34·1	+17·8
6– 9	4·1	+ 21·6	+ 76·2	+ 1·6	−16·0	−63·7	+34·1
9–12	3·8	+ 74·3	− 0·7	+23·9	−19·3	−22·6	+19·5
12–15	4·4	+ 53·6	+ 70·1	+22·0	+12·7	−61·4	+32·2
15–18	4·4	+ 21·3	+ 17·0	+ 3·5	−27·9	+ 5·1	+11·7
18–21	4·9	+ 68·4	+ 48·4	+46·7	−11·2	−20·7	+24·3
21–24	5·0	+103·8	+ 51·8	+13·9	+19·6	−34·3	+35·5
Mean	...	+ 66·8	+ 52·8	+19·3	− 2·3	−34·6	+29·9

TABLE XI. (x.)

Values of M_o.

	6°.0.	7°.5.	8°.5.	9°.0.	9°.4.	Mean Gradient.
Auwers	+46·7	+35·9	+19·1	0·0	−20·0	+18·9
Table X. (x) Means	+69·1	+55·1	+21·6	0·0	−32·3	+29·9

TABLE XII. (x).

Systematic P.M.'s in R.A. deduced from the 17½ years' interval between Cambridge Meridian Observations and Oxford Plates, assuming Auwers's determination of the Magnitude Equation to hold good in all R.A.'s.

Octant of R.A.	Mag. 6°.0. New.	Old.	Mag. 7°.5. New.	Old.	Mag. 8°.5. New.	Old.	Mag. 9°.0. New.	Old.	Mag. 9°.4. New.	Old.	Mean Grad. New. Detn.	Old. Table VII.
h h												
0− 3	+0·7	−6·3	+0·9	−5·5	+0·1	−2·1	−0·5	−2 6	−0·5	+0·9	+0·5	−2·1
3− 6	−0·5	+0·7	−0·9	+0·4	−0·3	+1·7	−0·2	+0·4	−0·8	+0·1	−0·1	−0·1
6− 9	−0·1	+1·4	−0·2	−2·5	−0·1	+0·9	0·0	+0·9	−0·6	+1·9	0·0	−0·8
9−12	−0·5	−2·1	−0·5	+1·6	−0·2	−0·4	−0·5	+0·6	−0·3	−0·1	−0·1	−0·1
12−15	−0·7	−1·1	−0·3	−2·2	−0·2	−0·4	−0·2	−1·0	−1·1	+1·3	0·0	−0·7
15−18	+0·1	+1·5	−0·5	+0·6	−0·4	+0·5	0·0	+1·5	−0·5	−1·9	0·0	+0·5
18−21	−0·1	−1·3	−0·1	−0·8	0·0	−1·4	+0·1	+0·7	−0·4	−0·3	0 0	−0·3
21−24	+0·3	−2·9	+0·1	−0·8	+0·4	+0·7	+0·1	−1·0	−0·5	+0·3	+0·1	−0·8

27. We may now proceed to repeat Table VIII. of the present paper with the new values of μ_α and μ_δ given in Tables XII. (y) and XII. (x).

TABLE XIII.

Corresponding to Table VIII., with the New Values of μ_α *and* μ_δ.

Octant.	μ_α.	sin (α−A).	$\mu_\alpha/\sin(\alpha-A)$.	μ_δ.	K.	μ_δ/K.	$\pm\mu_\alpha \pm\mu_\delta$. $\pm\sin(\alpha-A)\pm K$.	Gal. Lat.
h h								°
0− 3	+0·5	+·9	+0·6	−0·4	−·6	+0·7	+0·6	−34
3− 6	−0·1	+·4	−0·2	0·0	−·8	0·0	−0·1	−13
6− 9	0·0	−·4	0·0	−0·2	−·8	+0·3	+0·2	+22
9−12	−0·1	−·9	+0·1	−0·1	−·6	+0·2	+0·1	+61
12−15	0 0	−·9	0·0	+0·1	−·3	−0·3	−0·1	+80
15−18	0·0	−·4	0·0	+0·2	(−·1)	(−2·0)	−0·4	+40
18−21	0·0	+·4	0·0	+0·3	(−·1)	(−3·0)	−0·6	+ 2
21−24	+0·1	+·9	+0·1	0·0	−·3	0·0	+0·1	−25

28. The last two columns give the equivalent of Table IX., and we may now compare the values of $\varpi V \cos D \sec \delta$ for different galactic latitudes (as we did in § 14) given by the two methods.

Table XIV.

Octant.	18^h–21^h	3^h–6^h	6^h–9^h	21^h–24^h	0^h–3^h	15^h–18	9^h–12^h	12^h–15^h
Gal. Lat.	+ 2°	− 13°	+ 22°	− 25°	− 34°	+ 40°	+ 61 °	+ 80°
Old ...	−0·8	− 0·9	+ 0·6	− 1·3	− 2·3	− 0·4	− 0·5	+ 1·0
New ...	−0·6	− 0·1	+ 0·2	+ 0·1	+ 0·6	− 0·4	+ 0·1	− 0·1

29. It cannot be said that any conclusion emerges at present from such figures; the "new" and the "old" are almost irreconcilable. If the longer interval available for the "new" entitles them to preference, then we must frankly admit that the systematic proper motions found in the former paper (*Monthly Notices*, vol. lxiii. p. 56) and in the early part of this, and any conclusions based on them, are spurious. On the other hand we must remember that the "new" determinations are based on the assumptions—

(*a*) That the magnitude equation is sensibly the same for all R.A.'s.

(*b*) That Auwers's determination of it (in *Ast. Nach.* 3844) is correct.

Neither of these assumptions may be true, but they would have to be seriously wrong to remove the discordances made apparent in Table XIV.

30. It is easy to show the extent to which they must be in error by a graphical method. Let us suppose, as in §§ 17–19, that we are concerned with three definite epochs—1879·0, when the Cambridge observations were made; 1894·0, when the E plates were taken at Oxford; and 1899·0, when the L plates were taken—and for simplicity consider only the quantity which we have called the "mean gradient," which represents the difference *per magnitude* in units of 0″·03.

Let us plot the value of this quantity as ordinate against the date as abscissa. Then, if assumptions (*a*) and (*b*) of the last paragraph are correct, and our determinations of systematic proper motion in the different octants absolutely trustworthy, we should have a diagram like figure (1).

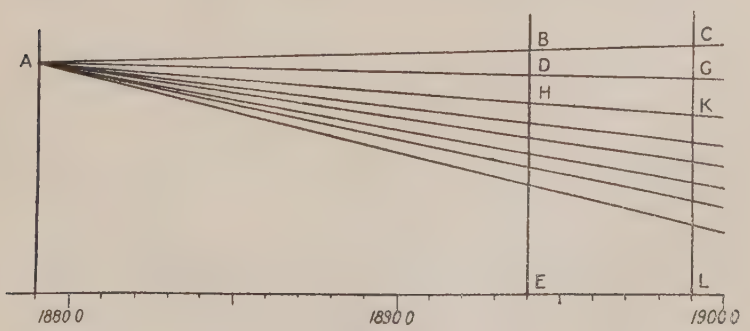

Fig. 1.

Representing the E value of the mean gradient in any given octant by the point B, and the L value by the point C, then the straight line BC, produced backwards, should pass through the point A, representing Auwers's mean gradient for 1879·0. And for other octants we should have lines ADG, AHK, &c., all passing through the point A.

31. If assumption (*b*) of § 29 is incorrect, but (*a*) still holds, then the various lines would still pass through a point on the line OA, though not the point A. Finally, if assumption (*a*) is incorrect, the eight lines will cut OA in eight different points; but unless the variation of magnitude equation with R.A. is comparable with its mean value, these eight points will be at distances from A small compared with AO.

32. It will be found on consideration of the formation of the last columns of Table X. (*y*) in § 20, and of Table X. (*x*) in § 26, that the quantities therein given represent the values of OA for the different octants. The arithmetical process used corresponds exactly to the production of lines joining points, such as C and B, backwards to cut the line OA.

33. To complete the diagram we want the slopes of the lines; and it is easily seen that these are given by the "old" system of systematic proper motions, as shown in the columns μ_α and μ_δ of Table VIII. in § 11. Hence we construct figures (2) and (3), which correspond to R.A. and declination.

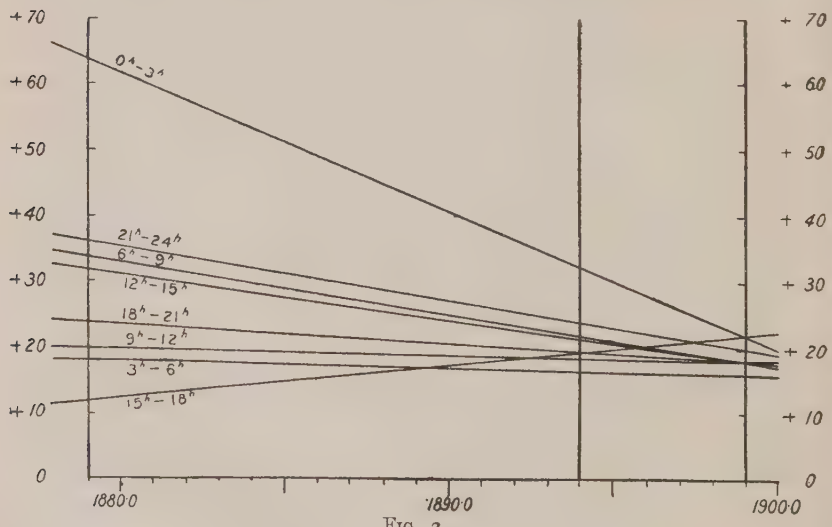

FIG. 2.

The lines are sometimes so close together that it is difficult to distinguish them, and the following small table, which gives the material for constructing the figures, may assist us to follow them. Under OA is given (omitting decimals) the value of the

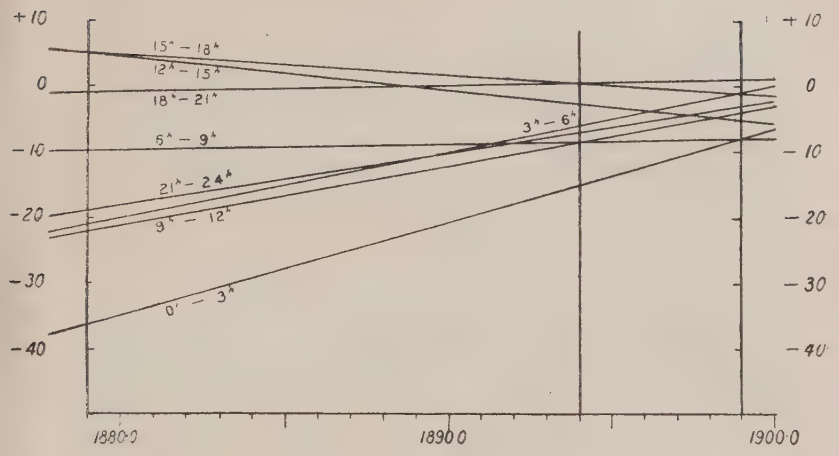

Fig. 3.

mean gradient in 1879·0, as shown in Tables X. (x) and X. (y). Adding twenty years' proper motions, as shown in the columns $20\mu_\alpha$ and $20\mu_\delta$ (got from Table VIII.), we find the values for epoch 1899·0 as shown in the columns headed LC.

Table XV.

Octant. h h	Fig. (1). OA.	$20\mu_\alpha$.	LC.	Fig. (2). OA.	$20\mu_\delta$.	LC.
0− 3	+64	−42	+22	−36	+28	−8
3− 6	+18	− 2	+16	−21	+20	−1
6− 9	+34	−16	+18	−10	+ 2	−8
9−12	+20	− 2	+18	−22	+18	−4
12−15	+32	−14	+18	+ 5	−10	−5
15−18	+12	+10	+22	+ 5	− 6	−1
18−21	+24	− 6	+18	− 1	+ 2	+1
21−24	+36	−16	+20	−19	+16	−3

34. It is apparent either from the figures or from Table XV. that the lines do not tend to converge to a point on the line for 1879·0. There is rather an apparent tendency to converge to a point on the line for 1899·0; but this is somewhat spurious. Producing the lines 20 years into the future it will be seen that the convergence is really to the epoch 1894–1899 generally, and is a natural effect of the admixture of "accidental" errors of some kind. These "accidental" errors may quite reasonably be assigned to real individual proper motions of the stars; but it is of course a possibility, which must be faced, that they are due to errors of measurement. Against this latter alternative we may,

however, set the number of plates measured, and the accordance shown by different zones in the former paper (§ 9, *Monthly Notices*, vol. lxiii. p. 60).

35. But it is clearly better to show at once the nature of the evidence previously collected ; and I should here acknowledge that Professor Seeliger has pointed out (*Ast. Nach.* 3865) from independent considerations that there must be a large element of accidental error in the results given in the former paper.

Summary.

36. (*a*) In a previous paper (*Monthly Notices*, vol. lxiii. p. 56) the relative systematic proper motions in R.A. of bright and faint stars in an interval of five years, as found from photographic plates taken at Oxford, were found by an indirect method, using Cambridge meridian observations made twenty years earlier as an intermediary.

(*b*) In the present paper the same method is extended to proper motions in declination.

(*c*) Attributing the proper motions so deduced to the parallactic effect of the Sun's motion in space, and determining thence the relative parallax of bright and faint stars in different octants of the R.A. circuit from the two components, a fair agreement was obtained, which suggested some reality for the determination (see § 15).

(*d*) But on using a different method for testing the results obtained they were not confirmed. This different method depends on one or more assumptions (see § 29), but it is not likely that these assumptions are so incorrect that the former method can still be accepted.

(*e*) It must, therefore, be admitted that either the interval of five years is not sufficiently long, in spite of the number of stars measured, to enable these relative proper motions to be determined, or that the systematic proper motions are so small compared with intrinsic proper motions that we require a much larger number of stars to get trustworthy mean values.

Errata in former paper (*Monthly Notices LXIII., pp.* 61, *&c.*).

Page 61. Last line but two : col. 2 *for* $-0\cdot9$ *read* $-1\cdot3$; col. 7 *for* $-0\cdot1$ *read* $-0\cdot3$; and col. 8 *for* $-0\cdot23$ *read* $-0\cdot33$.

,, 61. Last line : col. 2 *for* $-1\cdot21$ *read* $-1\cdot26$; col. 7 *for* $-0\cdot05$ *read* $-0\cdot08$; and col. 8 *for* $-0\cdot55$ *read* $-0\cdot56$.

,, 62. Table VIII. first line : *for* $-1\cdot21$ *read* $-1\cdot26$; *for* $+0\cdot44$ *read* $+0\cdot39$.

,, 68. Line 13 (18^h-21^h) *for* $-0\cdot2$ *read* $-0\cdot8$; *for* $-0\cdot6$ *read* $-0\cdot8$.

,, 68 Line 20 : *for* $-0\cdot6$ *read* $-0\cdot8$.

,, 68. Last line but three : *for* $a-2m$ *read* $a-2m$.

Preliminary Note on a Method of Photographing the Moon with Surrounding Stars. By H. H. Turner, D.Sc., F.R.S., Savilian Professor.

1. If the Moon and surrounding stars can be photographed simultaneously, we can measure the place of the Moon in the same way as that of a planet, comet, or other object, by reference to the surrounding stars; and such observations will be specially valuable near new Moon, when meridian observations are difficult or impossible. It was to obtain observations of the Moon in the first and last quarters that Airy set up the altazimuth at Greenwich in 1847; and unfortunately the instrument did not satisfactorily solve the problem. The present Astronomer Royal has recently set up a larger and steadier instrument with the same end in view, and already something is known of the success which is likely to attend the experiment. But even if early promise is fulfilled, there is ample room for an alternative photographic method.

2. It has for some time been in my mind to adapt for this purpose the method of observation suggested by Captain Hills, R.E., for obtaining terrestrial longitudes. (See *Mem. R.A.S.*, liii. p. 117.) With a fixed camera he takes snapshots of the Moon at times carefully recorded; and *at other times*, when the Moon has passed out of the field (or before it has entered it), a bright star or a planet is photographed on the same plate—several short trails being taken at recorded times. The method is applicable as it stands to the determination of the Moon's place, the disadvantages, however, being:

(*a*) Errors in recording the separate times of exposure enter directly into the inferred R.A. of the Moon.

(*b*) We can only use bright stars or planets, and must thus have rather a large field, or wait long intervals to secure them; perhaps both. The former condition means that the scale of the photograph will in general be small; the second introduces dangers of the camera being moved, or refraction changing considerably in the interval.

3. The second disadvantage can be considerably reduced by the device of a moving plate, moving at the same rate as the stars, and thus allowing faint stars to be impressed by accumulated exposure, which is not possible with trails. The position of the plate can be recorded by photographing on it a fixed point of light, the image of which is cut off automatically by the clock at regular intervals.

4. But a simpler expedient recently occurred to me as follows:—Point an ordinary photographic equatorial to the Moon and its surrounding stars and prepare in the usual way to take a photograph of the region, by an exposure of (say) one minute or of several minutes even, guiding on a star, so that stars of ninth

or tenth magnitude at least would in the ordinary course (*i.e.* if the Moon were not there) be impressed. But cover up the Moon by an opaque screen, C D E F, which is a rectangle of sides, C D, something more than the Moon's diameter, and C E double C D. Let there be a narrow slit, A B, across the middle, and during the exposure let the screen be slowly drawn across the Moon's image in the direction X Y. Then successive portions of the Moon are exposed for short periods determined by the width of the slit and the rate of travel. By selecting these elements properly we can get good definition on the Moon. The image will, of course, be a distorted image—an ellipse instead of a circle—and in measuring different craters on the Moon allowance must be made for the difference in epoch of exposure. The star images are produced by

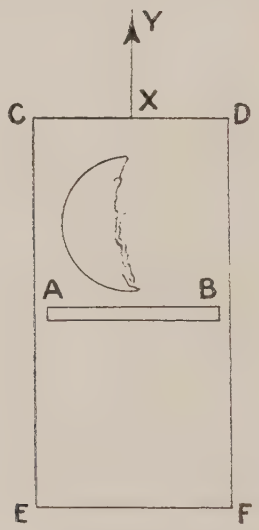

FIG. 1.

the summation of a series of exposures, each of which has a corresponding portion of the Moon ; and theoretically we should measure *every* portion of the Moon to get an accurate correspondence with the stars ; but in practice it will probably be found that sufficient accuracy is obtained by measuring a few well-selected craters. There is in any case an obvious gain over any method which gives one short exposure to the whole Moon and a longer exposure to the stars, leaving us all the uncertainties involved in finding the relation between the two exposures.

5. It will be seen that this method overcomes at once the two chief difficulties :

(*a*) The brightness of the Moon.

(*b*) Its rapid motion among the stars.

6. Several trials of the method have been made at Oxford with very promising results. The first was on October 26 about 6 P.M., when the Moon was about six days old: R.A. $19^h\ 0^m$, decl. $-17°\ 30'$; Z.D. about 70°. An exposure of three minutes was given. The screen was attached to a fixed object by a string, and thus the motion of the telescope automatically drew the screen across. On development the plate was, of course, found to be much fogged by the moonlight, but the following stars were easily recognised upon it.

	Zone.	No.	Mag.		Zone.	No.	Mag.
Schönfeld ...	−19°	5312	6·0	Schönfeld ...	−19°	5281	8·5
„ ...	−19	5273	6·1	„ ...	−19	5323	8·5
„ ...	−18	5206	6·5	„ ...	−19	5304	8·8
„ ...	−19	5275	7·0	„ ...	−19	5324	9·0
„ ...	−19	5317	7·4	„ ...	−18	5222	9·0
„ ...	−18	5219	7·8	„ ...	−18	5211	9·1

And there may be others also. Many stars are, of course, lost by the screen, and those in zone −17° were not looked for.

7. Other trials on October 28, October 30, and November 6 were made with shorter exposures as the brightness of the Moon increased, and ninth magnitude stars were not always shown, though there was no difficulty in getting eighth magnitude. These preliminary trials show that in the first and last quarters, which are the most important, we can get plenty of stars.

8. The screen may be trailed in any direction. The convenience of moving it in declination is that the whole length of path is approximately constant and equal to the Moon's diameter. But in some cases it might be more convenient to trail it in R.A. For instance, this method might be used in place of that of Captain Hills described in § 2, if a moving plate be provided. Point a *fixed* telescope to the region round the Moon, and let the plate move so as to follow the stars. Cover up the Moon with a *fixed* screen having a slit in it; the Moon's image will transit the slit along with the plate and give the desired result.

9. The method has the drawback common to all photographic methods, that it requires finer weather than eye observations. We can observe the Moon through cloud, but we can scarcely photograph faint stars. For this reason, if a successful attempt is to be made to get a good series of observations of the Moon near new Moon, photographs should be taken at more than one observatory.

10. We may hope by experiment to improve the details; but when such good results were obtained on the very first trial, it seems doubtful whether there is anything essential to be added. One small point may be noticed. To check the uniformity of motion of the slit, it is advisable to close the exposing shutter for a few seconds once or twice during the exposure, recording the

times carefully. Also care should be taken to provide that some portion of the Moon shall be shining through the slit during the whole of the exposure. It is, of course, not necessary to photograph the whole visible Moon.

11. The present note is written with the object of attracting attention to the method, which, it is hoped, will be tried at other observatories, especially those in fine climates. The new apparatus required is practically negligible. A good series of photographs of the Moon of this kind, taken day by day from last quarter to first quarter in lunations extending over a year, say, would be of immense value. By combination of observatories in different parts of the world a very complete series might be secured.

12. Attention may also be drawn to the note by Mr. B. H. Wade in the present number, on observations of the Moon as a possible check on longitude observations.

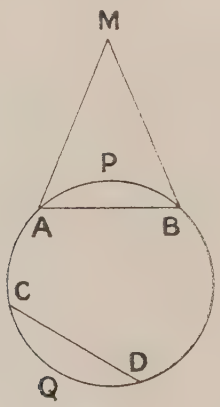

Fig. 2.

To state his point in rather different words : if we have two approximately equal arcs A B, C D on the Earth's surface, it is well known that we may test their equality in two ways.

(*a*) By direct (geodetic) measurement of the arcs A P B and C Q D.

(*b*) By astronomical observations of the angle between the verticals at A and B, using stars as an intermediary ; and similar observations of the angle between the verticals at C and D.

Mr. Wade points out that there is a third method, *independent* of these two, viz. :

(*c*) Observation of the angles subtended at the Moon by the chord A B and the chord C D.

13. These observations are comparatively rough owing to the great distance of the Moon ; but they may serve as a useful check, particularly if sufficient pains are spent on the lunar

observations, *e.g.* by numerous repetitions. If photographs of the Moon among the stars were assiduously taken over long periods at numerous observatories, it does not seem impossible that we might obtain ultimately information as to the figure of the Earth comparable in value with that derived from telegraphic longitudes. For at present the latter are only made at rare intervals ; and they are affected by some unknown, though small, sources of error, especially when submarine cables are employed. For instance, there is as yet no means of checking the fundamental assumption which enters into all telegraphic longitudes, that the time of transmission of an electric signal from A to B is the same as the time of return from B to A. The error of this assumption is no doubt a fraction of the whole time of transmission, but the latter may be as much as $0^{s}\cdot3$ across the Atlantic, and there is room for an error of $0^{s}\cdot05$ in the assumption of equal velocity to and fro. Good lunar observations systematically compared ought to be capable of easily checking such quantities as this.

Errors in the Moon's Tabular Longitude as affecting the comparison of the Greenwich Meridian Observations from 1750 *with Theory.* By P. H. Cowell.

(*Communicated by the Astronomer Royal.*)

I preface the account of my investigations with some extracts from the researches of various lunar theorists. I also exhibit a comparison between Airy's expression for the tabular longitude of the Moon and Hansen's. Had I realised when I made a certain analysis described in this paper that the errors of Airy's formula would produce a large systematic effect, as I endeavour to show in this paper that they do, my analysis would have taken a slightly different form. However, I now publish such results as I have obtained, and also the evidence on which I base the conclusion that the longitudes from 1750 to 1851 should be compared with a better formula than Airy's. I may also add that the bulk of the labour of this paper consisted in arranging the errors for analysis, and that this arrangement will enormously simplify the labour of correcting Airy's tabular places. The small fraction of the computations that represent the analysis after the arrangement was complete will in the near future be revised, but the provisional results are now published.

The arrangement which I refer to above as having formed the bulk of the labour is not described in this paper, nor are the details of the analysis. Complete information will be given with the corrected results.

The terms with coefficients over $0''\cdot3$, of which it is necessary to take account in the longitude of the Moon due to causes other

than the direct action of the Sun are approximately (1) terms due to planetary action, calculated by Radau (*Ann. de l'Observatoire de Paris, Mémoires*, vol. xxi.)

$$
\begin{aligned}
&- 0''.860 \sin (V-E)\\
&+ 0.283 \sin 2(V-E)\\
&- 0.681 \sin (g+2\varpi+3V-5E)\\
&- 0.348 \sin (2V-3E+85^\circ)\\
&+ 14.42 \sin (A+30^\circ) \text{ where } A = 18V-16E-g\\
&+ 0.806 \sin (A+30^\circ-g)\\
&+ 0.756 \sin (A+30^\circ+g)\\
&- 0.422 \sin (2M-E+49^\circ)\\
&+ 0.646 \sin (E-J)\\
&- 0.881 \sin (g+2\varpi-2J)\\
&+ 0.316 \sin (g+2\varpi-3J+7^\circ)
\end{aligned}
$$

to which may be added Newcomb's empirical alteration of a *Venus* term

$$-15''.5 \cos A(1+2e\cos g)$$

the second factor being introduced because $-15''.5 \cos A$ is a correction to the fundamental argument or mean anomaly. An effect which is just sensible is also produced by this term on the evection and variation ; (2) terms due to the figure of the Earth calculated by Hill (*Astron. Papers Amer. Eph.* vol. iii.)

$$
\begin{aligned}
&+ 7''.67 \sin \Omega\\
&+ 1.039 \sin \Omega \cos g\\
&+ 0.391 \sin (2g+2\varpi-\Omega)\,;
\end{aligned}
$$

(3) nutation, where two terms of Hansen are sensibly correct :

$$
\begin{aligned}
&- 17''.332 \sin \Omega\\
&- 1.254 \sin 2\odot
\end{aligned}
$$

Now the meridian observations at Greenwich since 1750 fall into four groups, of which the first two slightly overlap.

(1) 1750–1851, tabular places according to Airy's formula.

(2) 1847–1861, tabular places according to Hansen's tables, with an error of sign corrected.

(3) 1862–1882, tabular places according to Hansen's tables unaltered.

(4) 1883 onwards, tabular places according to Hansen's tables, with an error of sign corrected and Newcomb's corrections introduced.

Before coming to the solar terms I set down here the corrections required by Airy and Hansen's tabular longitude to reduce them to the above formulæ, terms less than $0''.3$ being omitted.

Corrections common to all four periods:

$$-0''.681 \sin (g+2\varpi+3V-5E)$$
$$-0.348 \sin (2V-3E+85^\circ)$$
$$-0.881 \sin (g+2\varpi-2J)$$
$$+0.316 \sin (g+2\varpi-3J+7^\circ)$$

Additional corrections required in the first period:

$$+14''.42 \sin (A+30^\circ)$$
$$+ 1.562 \sin (A+30^\circ) \cos g$$
$$- 0.422 \sin (2M-E+49^\circ)$$
$$-15.5 \cos A\,(1+2e \cos g)$$
$$+ 0.45 \sin \Omega$$
$$+ 1.039 \sin \quad \cos g$$

It will be noticed that Airy gives a figure of the Earth term omitted by Hansen, and that in the coefficient of sin ☊ Airy makes two errors that nearly cancel, the term occurring both in figure of Earth and nutation.

Additional corrections required by all tabular longitudes based on Hansen's tables:

$$-0''.92 \sin (A+30^\circ)$$
$$+0.63 \cos \Omega$$
$$+0.445 \sin \Omega \cos g$$
$$+0.391 \sin (2g+2\varpi-\Omega)$$

Further additional corrections required in the period 1847–1882:

$$[1+2e \cos g]\,[-21''.47 \sin (8V-13E+274^\circ\,14')$$
$$-1''.14-29''.17t-3''.76\,t^2-15''.5 \cos A]$$

and in the period 1862–1882 a still further correction

$$-0''.62 \sin (2g-4g'+2\omega-4\omega')$$

Of the term $+0''.63 \cos \Omega$ it may be mentioned that it is inserted to reduce Hansen's figure of the Earth terms to pure theory in accordance with Hill's calculations. Airy found $-1''.06 \cos \Omega$ from the observations 1750–1851, and Hansen has apparently adopted the term with its coefficient reduced. It

will be seen in the latter part of this paper that a coefficient of the principal elliptic term 22639″·6 is obtained, whereas Airy has obtained 22639″·1. This paper sufficiently explains why Airy's value is wrong. I however tried to find a similar explanation of this cos 8 term, and I have not succeeded; so that at the present moment I do not know whether the term really exists or not.

In the following table of solar terms in the Moon's longitude with coefficients of 0″·4 or more the *first* column gives a reference number; the *second* column classifies the term with reference to the discussion below in cases when Airy's coefficient appears to be 0″·4 or more in error; the *third*, *fourth*, and *fifth* columns exhibit the argument as sums of multiples of g, g', ω, ω'; D, g, g', F; D, g, ω, ω' respectively. The first method is Hansen's: its convenience is that the approximate period of the term is obvious from inspection; the second method is that used by Airy, Delaunay, Brown, and others: its convenience is that it gives the "characteristic" of the coefficient; the third method bears reference to the present paper; the *sixth* column gives the coefficient according to Newcomb's transformation of Hansen's theory (*Astron. Papers of Amer. Eph.* vol. i.); these coefficients correspond to the eccentricity of Hansen's tables, and to a solar parallax of 8″·848, which is not the parallax of Hansen's tables. Newcomb's comparison with Delaunay shows that these coefficients are subject to small errors only; Hansen's tables differ from Hansen's theory very slightly by quantities seldom exceeding 0″·3; the *seventh* column gives Airy's coefficient. Airy accepted Damoiseau's values of the arguments, but revised his coefficients. His action has been most unfortunate, as Damoiseau's coefficients were much superior to those that Airy substituted, and in particular Damoiseau's coefficient of the principal elliptic term was practically correct; the *eighth* column gives estimates of the correct value of two coefficients, and the consequent change in a third; the *ninth* column gives the correction to Airy's coefficient.

TABLE I.

Ref. No.	Class.	Argument expressed in Multiples of									Coefficient in Hansen's Theory modified by Newcomb.	Coefficient in Airy's Reductions.	Approximate true Value.	Correction required by Airy.
		g	g'	ω	ω'	D	g	g' F	D	g	ω	ω'				
1	A	1	...	...	...	0,	1,	0, 0	0,	1	...	...	+22640″15	+22641″6	+22639″6	−2″0
2	C	2	...	...	...	0,	2,	0, 0	0,	2	...	...	+ 769·06	+ 769·5	...	−0·4
3	C	3	...	...	...	0,	3,	0, 0	0,	3	...	...	+ 36·13	+ 36·7	...	−0·6
4	...	4	...	...	...	0,	4,	0, 0	0,	4	...	...	+ 1·94	+ 2·0	...	...
5	...	−3,	−1	...	...	0,	−3,	−1, 0	1,	−4,	−1,	1	+ 0·55	+ 0·4	...	...
6	C	−2,	−1	...	...	0,	−2,	−1, 0	1,	−3,	−1,	1	+ 7·67	+ 7·3	...	+0·4
7	C	−1,	−1	...	...	0,	−1,	−1, 0	1,	−2,	−1,	1	+ 109·92	+ 111·1	...	−1·2
8	B	0,	−1	...	...	0,	0,	−1, 0	1,	−1,	−1,	1	+ 669·85	+ 668·6	...	+1·2
9	...	1,	−1	...	...	0,	1,	−1, 0	1,	0,	−1,	1	+ 148·02	+ 148·1	...	...
10	...	2,	1	...	...	0,	2,	−1, 0	1,	1,	−1,	1	+ 9·72	+ 9·6	...	...
11	...	3,	−1	...	...	0,	3,	−1, 0	1,	2,	−1,	1	+ 0·67	+ 0·4	...	...
12	...	−1,	2	...	...	0,	−1,	−2, 0	2,	−3,	−2,	2	+ 1·18	+ 1·2	...	...
13	C	0,	−2	...	...	0,	0,	−2, 0	2,	−2,	−2,	2	+ 7·51	+ 7·9	...	−0·4
14	B	1,	−2	...	...	0,	1,	−2, 0	2,	−1,	−2,	2	+ 2·59	+ 2·1	...	+0·5
15	A	1,	0,	2,	−2	2,	−1,	2, 0	0,	1,	2,	−2	− 2·54	− 2·0	...	−0·5
16	B	0,	−1,	2,	−2	2,	−2,	1, 0	1,	−1,	1,	−1	+ 2·52	− 1·4	...	+3·9
17	...	1,	−1,	2,	−2	2,	−1,	1, 0	1,	0,	1,	−1	− 28·56	− 28·8	...	...
18	B	2,	−1,	2,	−2	2,	0,	1, 0	1,	1,	1,	−1	− 24·45	− 23·6	...	−0·8
19	...	3,	1,	2,	−2	2,	1,	1, 0	1,	2,	1,	−1	− 2·93	− 2·9	...	...
20	...	−2,	−2,	2,	−2	2,	−4,	0, 0	2,	−4,	0,	0	+ 0·95	+ 0·9	...	...

Ref. No.	Class.	Argument expressed in Multiples of										Coefficient in Hansen's Theory modified by Newcomb.	Coefficient in Airy's Reductions	Approximate true Value.	Correction required by Airy.
		g	g'	ω	ω'	D	g	g'	F	D	g	ω	ω'				
21	C	−1,	−2,	2,	−2	2,	−3,	0,	0	2,	−3,	0,	0	+ 13″·19	+ 12″·8	… ″	+ 0″·4
22	C	0,	−2,	2,	−2	2,	−2,	0,	0	2,	−2,	0,	0	+ 211·71	+ 212·4	…	0·7
23	B	1,	−2,	2,	−2	2,	−1,	0,	0	2,	−1,	0,	0	+ 4586·56	+ 4585·6	+ 4586·4	+ 0·8
24	C	2,	−2,	2,	−2	2,	0,	0,	0	2,	0,	0,	0	+ 2369·75	+ 2370·3	…	− 0·5
25	…	3,	−2,	2,	−2	2,	1,	0,	0	2,	1,	0,	0	+ 191·95	+ 192·1	…	…
26	…	4,	−2,	2,	−2	2,	2,	0,	0	2,	2,	0,	0	+ 14·38	+ 14·1	…	…
27	…	5,	−2,	2,	−2	2,	3,	0,	0	2,	3,	0,	0	+ 1·06	+ 0·8	…	…
28	…	−1,	−3	2,	−2	2,	−3,	−1,	0	3,	−4,	−1,	1	+ 0·48	+ 0·3	…	…
29	C	0,	−3,	2,	−2	2,	−2,	−1,	0	3,	−3,	−1,	1	+ 8·66	+ 7·8	…	+ 0·9
30	C	1,	−3,	2,	−2	2,	−1,	−1,	0	3,	−2,	−1,	1	+ 206·46	+ 209·7	…	− 3·2
31	B	2,	−3,	2,	−2	2,	0,	−1,	0	3,	−1,	−1,	1	+ 165·52	+ 165·9	…	− 0·4
32	C	3,	−3,	2,	−2	2,	1,	−1,	0	3,	0,	−1,	1	+ 14·60	+ 14·0	…	+ 0·6
33	B	4,	−3,	2,	−2	2,	2,	−1,	0	3,	1,	−1,	1	+ 1·18	+ 0·6	…	+ 0·6
34	…	1,	−4,	2,	−2	2,	−1,	−2,	0	4,	−3,	−2,	2	+ 7·44	+ 7·5	…	…
35	…	2,	−4,	2,	−2	2,	0,	−2,	0	4,	−2,	−2,	2	+ 8·13	+ 7·8	…	…
36	B	3,	−4,	2,	−2	2,	1,	−2,	0	4,	−1,	−2,	2	+ 0·76	+ 0·3	…	+ 0·5
37	C	2,	1,	2	…	0,	0,	1,	2	−1,	3,	3,	−1	+ 0·42	…	…	+ 0·4
38	…	…	…	2	…	0,	−2,	0,	2	0,	0,	2,	0	+ 1·09	+ 1·1	…	…
39	A	1,	0,	2	…	0,	−1,	0,	2	0,	1,	2,	0	− 39·58	− 37·2	…	− 2·4
40	C	2,	0,	2	…	0,	0,	0,	2	0,	2,	2,	0	− 411·60	− 411·0	…	− 0·6
41	…	3,	0,	2	…	0,	1,	0,	2	0,	3,	2,	0	− 45·09	− 45·2	…	…

Ref. No.	Class.	Argument expressed in Multiples of										Coefficient in Hansen's Theory modified by Newcomb.		Coefficient in Airy's Reductions.		Approximate true Value.	Correction required by Airy.
		g	g'	ω	ω'	D	g	g'	F	D	g	ω	ω'							
															"		"		"	"
42	...	4,	0,	2	...	0,	2,	0,	2	0,	4,	2,	0	−	4·00	−	4·1	...	...	
43	C	−1,	3,	0,	2	−2,	−1,	1,	2	−3,	2,	3,	−1	+	0·40		...	...	+0·4	
44	...	0,	3,	0,	2	−2,	0,	1,	2	−3,	3,	3,	−1	−	2·15	−	2·3	...	...	
45	...	−2,	2,	0,	2	−2,	−2,	0,	2	−2,	0,	2,	0	+	0·43	+	0·5	...	...	
46	...	1,	2,	0,	2	−2,	−1,	0,	2	−2,	1,	2,	0	+	6·36	+	6·2	...	...	
47	...	0,	2,	0,	2	−2,	0,	0,	2	−2,	2,	2,	0	−	55·25	−	54·9	...	...	
48	C	2,	2,	0,	2	−2,	2,	0,	2	−2,	4,	2,	0	+	0·56	+	0·2	...	+0·4	
49	...	0,	1,	0,	2	−2,	0,	−1,	2	−1,	1,	1,	1	+	1·55	+	1·5	...	...	
50	C	0,	0,	1,	−1	1,	−1,	1,	0	0,	0,	1,	−1	+	1·33	+	0·5	...	+0·8	
51	A	1,	0,	1,	1	1,	0,	1,	0	0,	1,	1,	1	+	18·09	+	17·2	...	+0·9	
52	...	2,	0,	1,	−1	1,	1,	1,	0	0,	2,	1,	−1	+	1·27	+	1·0	...	...	
53	C	−1,	−1,	1,	−1	1,	−2,	0,	0	1,	−2,	0,	0	−	1·78	−	0·8	...	−1·0	
54	B	0,	−1,	1,	−1	1,	−1,	0,	0	1,	−1,	0,	0	−	18·70	−	18·0	...	−0·7	
55	C	1,	−1,	1,	−1	1,	0,	0,	0	1,	0,	0,	0	−	125·43	−	122 1	− 124·8	−2·7	
56	...	2,	1,	1,	−1	1,	1,	0,	0	1,	1,	0,	0	−	8·48	−	8·2	...	...	
57	...	3,	1,	1,	−1	1,	2,	0	0	1,	2,	0,	0	−	0·59	−	0·4	...	...	
58	...	1,	2,	1,	1	1,	0,	−1,	0	2,	−1,	−1,	1	−	0·60	−	0·4	...	...	
59	C	1,	3,	3,	3	3,	−2,	0,	0	3,	−2,	0,	0	−	1·22	−	0·6	...	−0·6	
60	...	2,	−3,	3,	3	3,	−1,	0,	0	3,	−1,	0,	0	−	3·23	−	3·0	...	...	
61	C	3,	−3,	3,	−3	3,	0,	0,	0	3,	0,	0,	0	+	0·41	+	0·9	...	−0·5	

Ref. No.	Class.	Argument expressed in Multiples of										Coefficient in Hansen's Theory modified by Newcomb.		Coefficient in Airy's Reductions.		Approximate true Value.	Correction required by Airy.
		g	g'	ω	ω'	D	g	g'	F	D	g	ω	ω'								
62	...	1,	1,	1,	1	1,	0,	0,	2	−1,	2,	2,	0	+	0·55	+	0·7	...	...
63	...	3,	−3,	4,	4	4,	−1,	1,	0	3,	0,	1,	−1	−	0·64	−	0·9	...	...
64	...	2,	−3,	4,	4	4,	−2,	1,	0	3,	−1,	1,	−1	−	0·36	−	0·5	...	...
65	C	1,	−4,	4,	4	4,	−3,	0,	0	4,	−3,	0,	0	+	1·18	+	0·5	...	+0·7
66	C	2,	−4,	4,	4	4,	−2,	0,	0	4,	−2,	0,	0	+	30·78	+	34·5	...	−3·7
67	B	3,	−4,	4,	4	4,	−1,	0,	0	4,	−1,	0,	0	+	38·43	+	38·0	...	+0·4
68	C	4,	−4,	4,	4	4,	0,	0,	0	4,	0,	0,	0	+	13·90	+	14·4	...	−0·5
69	B	5,	−4,	4,	4	4,	1,	0,	0	4,	1,	0,	0	+	1·98	+	0·9	...	+1·1
70	C	2,	−5,	4,	−4	4,	−2,	−1,	0	5,	−3,	−1,	1	+	2·75	+	1·2	...	+1·5
71	C	3,	−5,	4,	4	4,	−1,	−1,	0	5,	−2,	−1,	1	+	4·41	+	3·8	...	+0·6
72	B	4,	−5,	4,	4	4,	0,	−1,	0	5,	−1,	−1,	1	+	1·89	+	1·2	...	+0·7
73	C	2,	−2,	4,	−2	2,	−2,	0,	2	2,	0,	2,	0	−	0·54	−	0·9	...	+0·4
74	...	3,	−2,	4,	−2	2,	−1,	0,	2	2,	1,	2,	0	−	9·37	−	9·4	...	...
75	C	4,	−2,	4,	−2	2,	0,	0,	2	2,	2,	2,	0	−	5·74	−	3·4	...	−2·3
76	C	5,	−2,	4,	−2	2,	1,	0,	2	2,	3,	2,	0	−	0·99	−	0·6	...	−0·4
77	C	3,	−3,	4,	−2	2,	−1,	−1,	2	3,	0,	1,	1	−	0·43	...		...	−0·4
78	C	4,	−6,	6,	−6	6,	−2,	0,	0	6,	−2,	0,	0	+	0·57		0·0	...	+0·6
79	B	5,	−6,	6,	−6	6,	−1,	0,	0	6,	−1,	0,	0	+	0·40	...		...	+0·4
80	...	4,	0,	4,	0	0,	0,	0,	4	0,	4,	4,	0	+	0·42	+	0·4	...	...

In addition to the above erroneous coefficients, Airy, through a clerical error, altered the argument of a term with coefficient $0''\cdot4$; that is to say, he left out one term and put in another. The term that he left out has a coefficient of $0''\cdot22$ in Hansen, so that it does not much matter whether it was left out or inserted. It is not given in the above table. The term substituted has, according to Hansen, no sensible coefficient. Airy's tabular longitudes therefore require a further correction :

$$+0''\cdot4 \sin(-4D+g'+2F)$$

The argument may also be written

$$-2g+5g'-2\omega+4\omega'$$

or

$$-5D+3g+3\omega-\omega'$$

I shall now give a brief account of an investigation on which I have been employed during the last few months.

The tabular *minus* observed errors of the right ascensions from 1883 to 1898 were corrected by $+0^s\cdot133 \sin D$ for parallactic inequality, and analysed for the coefficients of $\cos g$ and $\sin g$. The errors were, in fact, equated to

$$c+a\cos g+b\sin g$$

and c, a, b obtained by a rigorous least-squares solution (see *Observatory Magazine* for 1903 September). The results obtained were :

α. On correcting a and b for certain planetary and figure of Earth terms, their accordance was improved in the ratio of 5 : 2.

β. A suspicion arose of a term with coefficient $0''\cdot5$ and argument differing from the mean anomaly by an angle whose mean motion is approximately that of the perigee.

γ. A correction to the coefficient of the principal elliptic term $-0''\cdot50$ was obtained.

δ. A correction of $-1''\cdot41 \div 0\cdot1098$ (twice the eccentricity) is required by Hansen's mean anomaly, as corrected by Newcomb in 1891, on the assumption that it is proper to reject Newcomb's empirical alteration of a certain *Venus* term. If this empirical alteration is retained the correction is one-third of the above amount.

With the object of getting fresh light on result β, I next analysed the longitudes 1750–1851, without, however, correcting the parallactic term, or any other term, in the tabular places. After equating the errors in turn to c, $a\cos g$, and $b\sin g$, and solving by least squares, I obtained values of c, a, b for eighty-nine periods of 400 lunar days into which the century's observations may be divided. Four hundred lunar days were taken as the period of analysis as being approximately equal to fifteen anomalistic months and fourteen lunations. These values of a

and b were corrected for planetary terms, and also for the solar terms Nos. 15, 39, 51 in the preceding list. Newcomb's empirical term was not inserted. There remained in the corrected values of a and b large accidental errors, and also some signs of periodicity with considerable coefficients. The accidental errors I attribute to the errors of Airy's formula for the tabular longitude, which, as the preceding table shows, are considerable. The periodicity cannot be an unknown term in the Moon's motion, as it would have appeared in 1883–1898 ; it is not likely to be due to systematic errors of observation, for the period is an unlikely one to arise from this cause. I attribute it to the terms marked B in the foregoing table. Possibly also the small term in the observations 1883 1898 arises in a similar manner.

It will be seen that terms of class A can be corrected for, in the values of a and b, after solution. For example, take term No. 39 : here Airy's tabular place requires a correction $-2''\cdot38 \sin(g+2\omega)$; during a period of analysis in which g, it will be remembered, completes fifteen revolutions, 2ω moves 136°. If its variations, $\pm 68°$ on each side of its mean value, could be ignored, the correction to a would be $-2''\cdot38 \sin 2\omega$, and to b $-2''\cdot38 \cos 2\omega$; the coefficient has, however, been reduced to $-1''\cdot87$ as an expression of the fact that the centre of gravity of an arc of a circle is not on its circumference.

The effect of terms of class C is, I believe, purely accidental. As about 120 observations were usually to be found in a period of analysis, and as a and b are determined from these observations, with weights $\cos^2 g$ and $\sin^2 g$ respectively, the accidental errors of a and b on this account should be about one-eighth of the accidental errors of the tabular place. The last column of the table suggests $4''\cdot4$ as the probable error of a tabular place, and therefore $0''\cdot55$ as the probable error of a and b for one period. The effect of terms of class B would be accidental were it not for the fact that the observations are systematically distributed with regard to D, the age of the Moon. Let us take term No. 16 as an illustration. The formula for a is

$$a = \frac{\Sigma \text{ error} \times \cos g}{\Sigma \cos^2 g}$$

hence the systematic effect of a correction

$$+3''\cdot92 \sin(D - g + \omega - \omega')$$

in the tabular place will be (over and above a considerable addition to the accidental error) approximately the mean value of

$$3''\cdot92 \sin(D + \omega - \omega')$$

or

$$3''\cdot92 \sin(\omega - \omega') \times \text{mean value of } \cos D$$
$$+ 3''\cdot92 \cos(\omega - \omega') \times \text{mean value of } \sin D$$

As a rough estimate, I should equate this to

$$3''\cdot92 \sin(\omega-\omega') \times -\tfrac{4}{9}$$
$$+3''\cdot92 \cos(\omega-\omega') \times +\tfrac{1}{10}$$

but it is clear that a very considerable periodicity may easily result.

It is not surprising, therefore, that I have not obtained as yet any additional light on the suspected periodic term in the 1883–1898 observations. In fact, the individual values of a and b are worthless, except as confirming the above conclusions, and they should be grouped eight at a time, eight periods of analysis being approximately the period of $\omega-\omega'$, the argument of the above inequality.

Turning now to term 54 in the above list, reasoning similar to the above indicates a correction to a equal to $-0''\cdot7 \times$ mean value of $\sin D = -0''\cdot07$ nearly, and a correction to b equal to $+0''\cdot7 \times$ mean value of $\cos D$, or $-0''\cdot31$ nearly. This latter quantity is introduced into the estimate of the principal elliptic coefficient made later in this paper.

The following table gives the corrected values of a, b for the means of eight periods, which are approximately equivalent to nine years. The values here given are corrected for solar terms 15, 39, 51, and also for five planetary terms (or figure of Earth) of analogous form ; that is to say, the arguments differ from g by angles of very long period.

Period.	a.	b.	Period.	a.	b.
	″	″		″	″
1– 8	+0·41	+1·49	49–56	−0·61	+2·60
5–12	+0·18	+1·84	53–60	−0·19	+2·68
9–16	−0·14	+1·63	57–64	−0·15	+2·44
13–20	−0·63	+2·00	61–68	−0·26	+2·10
17–24	−0·38	+2·60	65–72	+0·09	+2·22
21–28	−0·34	+2·49	69–76	−0·28	+2·60
25–32	−0·45	+2·27	73–80	+0·24	+2·86
29–36	−0·73	+2·40	77–84	+0·77	+2·05
33–40	−0·39	+2·41	81–88	+0·19	+2·00
37–44	−0·58	+1·48			
41–48	−0·45	+1·95	Mean	−0·21	+2·22
45–52	−0·72	+2·61			

From these figures I draw the following conclusions :

ϵ. A correction $-2''\cdot22$ is apparently required by the principal elliptic coefficient, but this requires modification by about $+0''\cdot19$ on account of terms Nos. 54 and 56 of the first table. This gives the true coefficient as $22639''\cdot57$, while the R.A.'s 1883–1898 gave $22639''\cdot65$. Newcomb has given $22639''\cdot58$.

ζ. Damoiseau's mean anomaly for 1800 requires an increase

of about 2″, and its mean motion is nearly correct if we ignore long-period corrections (among them Newcomb's empirical correction) and secular terms.

η. The correction a in 1891 is +1″·41, which becomes +2″·16 if Damoiseau's value for the mean anomaly is used. This is quite inconsistent with the above values of a, except on the assumption that there is a long-period term or secular correction required.

Newcomb's empirical *Venus* term supplies about the right amount of curvature, its values in 1750, 1800, 1850 and 1891 being

$$+0''\cdot86,\ +1''\cdot70,\ +0''\cdot58,\ -0''\cdot96$$

making the value of a fairly constant and equal to +1″·2, implying that Damoiseau's value of the mean anomaly is too large by 11″, or that the Hansen–Newcomb value requires a correction

$$+4''\cdot6-14''\cdot0t+4''\cdot7t^2$$

reckoning t in centuries from 1800, a formula whose values are probably within 5″ of the truth from 1750 to 1900.

I have shown in the *Observatory Magazine* for 1903 November that the consequence of assuming that no long-period terms exist other than those known from gravitational theory is that the secular term in the mean anomaly must be halved.

θ. My last conclusion is that it would be well worth while to correct Airy's tabular places for most of the larger inequalities. In Table I. a list of 47 inequalities of 0″·4 or greater is given (which can be reduced to 22 by omitting inequalities of less than 0″·7, though I do not think that this is desirable). The sum of the coefficients without regard to sign is 46″, and the probable error of a tabular place can hardly be less than 4″·4. The probable error of a discordance between theory and observation is probably capable therefore of being divided by 3, or in other words imperfections in the tabular places have hitherto reduced the weight of this century of observations to one-ninth of the value they might have. At the same time it would be worth while to similarly correct the comparison with Hansen for parallactic inequality, planetary terms, and correction to the principal elliptic inequality and value of the mean anomaly, the corrections being adjusted so that the tabular places may be as nearly continuous as possible.

Finally I give here the separate values of c, a, and b for each period, the a's and b's being corrected for the effect of terms of class A, Nos. 15, 39, and 51, and planetary terms belonging to the same class.

None of the numerical conclusions of this paper are based upon these separate values, but only on the means of eight. The separate values are given here as evidence of the necessity for revising Airy's formulæ.

Period.	No. of Obs.	c	a Corrected.	b Corrected.	Period.	No. of Obs.	c	a Corrected.	b Corrected.
		"	"	"			"	"	"
1	115	+3·38	+3·49	+1·94	40	131	−6·08	+1·09	+1·02
2	141	+2·64	+0·98	+2·59	41	127	−1·04	−0·78	+1·93
3	148	+4·02	−0·76	+0·98	42	101	−2·42	−2·25	+2·20
4	128	+3·27	−1·38	+4·05	43	127	−0·99	−1·15	+2·87
5	125	+2·60	−0·39	+0·53	44	112	−1·41	−2·70	+1·04
6	125	+0·60	−0·31	−0·03	45	145	−0·75	−1·02	+1·82
7	123	+1·29	+0·24	+0·77	46	165	−0·27	+0·93	+2·19
8	152	+1·40	+1·45	+1·07	47	158	−1·26	+3·77	+1·42
9	120	+1·68	+0·64	+3·44	48	110	−1·33	−0·38	+2·18
10	72	+0·25	+2·10	+4·41	49	119	−0·05	−1·99	+4·67
11	61	+2·50	+0·54	+2·15	50	127	−0·92	−1·61	+3·70
12	91	+2·44	−2·80	+2·38	51	132	−0·78	−3·12	+3·24
13	42	−1·79	−1·57	−2·07	52	112	−1·00	−2·34	+1·65
14	115	−0·86	−0·95	−0·45	53	117	−2·95	+0·94	+1·76
15	129	+1·11	−0·13	−0·04	54	118	−0·56	+1·03	+1·44
16	123	−1·14	+1·08	+3·24	55	119	−0·86	+1·47	+0·90
17	129	−3·72	+0·49	+4·21	56	128	−1·99	+0·77	+3·47
18	121	−4·62	−1·54	+4·01	57	87	+0·07	+0·37	+5·55
19	111	−0·26	−1·38	+3·14	58	109	+1·55	−2·21	+4·47
20	82	−0·16	−1·04	+3·95	59	93	+2·66	−2·50	+3·45
21	125	−1·98	−0·60	+0·24	60	105	+1·54	−1·40	+0·38
22	100	−4·25	−0·94	−0·01	61	109	+2·77	+0·59	+0·68
23	96	−4·34	+1·22	+2·09	62	118	+2·77	−0·12	+1·10
24	142	−3·90	+0·73	+3·15	63	123	+0·64	+1·92	+1·73
25	129	−5·61	−1·50	+6·34	64	126	+0·76	+2·12	+2·20
26	63	−2·58	−1·75	+3·10	65	112	+1·02	−1·34	+4·56
27	114	−3·21	+1·83	+3·21	66	84	+1·14	−1·30	+4·64
28	101	−1·68	−1·72	+1·78	67	126	+0·74	−2·65	+1·66
29	136	−3·12	−0·59	+0·84	68	117	+0·80	−1·31	+0·24
30	110	−2·84	+0·59	−0·82	69	112	+1·53	+0·45	+0·20
31	129	−2·82	+0·35	+1·42	70	92	−0·09	+0·81	+0·28
32	124	−3·73	−0·85	+2·27	71	104	+0·68	+3·32	+1·94
33	127	−4·49	+0·09	+3·78	72	102	+2·15	+2·72	+4·26
34	123	−4·91	−1·09	+7·09	73	81	+3·95	−0·37	+3·43
35	126	−4·27	−2·65	+3·24	74	103	+0·90	−1·70	+5·24
36	105	−5·13	−1·73	+1·37	75	115	+2·25	−1·83	+3·37
37	117	−5·08	+0·89	−0·70	76	92	+1·81	−1·14	+2·11
38	111	−4·19	−0·27	+0·38	77	100	+1·09	+1·87	+1·51
39	117	−6·21	+0·51	+3·07	78	104	+1·65	+2·42	+0·85

Period.	No. of Obs.	c	a Corrected.	b Corrected.	Period.	No. of Obs.	c	a Corrected.	b Corrected.
		"	"	"			"	"	"
79	112	+1·64	+3·05	+2·24	85	125	−1·04	+0·91	−0·44
80	111	+1·20	−0·41	+4·13	86	120	−0·62	+1·10	+2·77
81	122	+0·30	+0·85	+3·46	87	136	−2·53	+0·55	+1·90
82	99	−0·40	−1·42	+3·91	88	123	−2·91	−0·25	+4·14
83	132	−1·00	−0·96	+0·86	89	123	−3·88	−2·72	+3·47
84	105	−2·69	+0·76	−0·56					

On the Large Sun-spots of 1903 *October* 4–18 *and October* 25–*November* 6, *and the Associated Magnetic Disturbances.*

(*Communicated by the Astronomer Royal.*)

As two striking instances have occurred in less than three weeks of a marked magnetic disturbance simultaneous with the appearance of a great group of spots near the centre of the Sun's disc, some particulars of both phenomena may be of interest, though there has not been time as yet to do more than measure and reduce two or three of the photographs taken of the Sun, and though the record is imperfect until the arrival of photographs from India and Mauritius to supplement the Greenwich series.

The two groups of spots in question were both in the southern hemisphere, and both very nearly in the same latitude. The first to appear was very much the larger, and may be distinguished as the Great Southern Group; whilst the other may be termed the Second or Smaller Southern Group.

The Great Southern Group was first seen on the east limb on October 4, when a regular spot of no great area came into view. The rest of the group was not completely seen until October 5, the above-mentioned leader being separated by nearly 3° of heliographic longitude from the next portion of the group. The entire length of the group as measured on October 9 was more than 17°, and its greatest breadth in heliographic latitude was 6°·7. Its total area on this day was 2080, as expressed in the usual unit—millionths of the Sun's visible hemisphere.

The heliographic latitude of the centre of the principal spot was −21°. The heliographic longitude of the same point was 205°·5. The positions of this point relative to the central meridian of the Sun, at the times when the magnetic disturbance began and ended, and when its most marked phase began and ended, were as follows :—

Magnetic Disturbance.	Greenwich Civil Time.	Longitude of C.M.	Longitude of Spot from C.M.
	d h	°	°
Disturbance began	Oct. 12 18	188·2	17·3 W.
Most marked phase began ...	12 20	187·1	18·4
Most marked phase ended ...	13 3	183·2	22 3
Disturbance ended	13 4	182·6	22·9

The longitude of the central meridian of the Sun at noon on October 10 was 217°·8 ; on October 11, 204°·6 ; on October 12, 191°·5. The leader spot of the group reached the central meridian about October 10^d 18^h ; the centre of the principal spot about October 11^d 8^h ; the last spots of the group passing about October 12^d 8^h ; Greenwich Civil Time being used throughout.

The group underwent great and rapid changes of form ; its chief characteristics being the number and complexity of the bright bridges which invaded it. Thus on October 9 a very broad bright bridge entered the principal spot from the west, and stretched out in an undulating line towards the east, almost obliterating the umbra, and dividing the spot itself into two elongated and parallel sections. The after-part of the group was even more completely divided by bright material, crossing it in both the east and west and the north and south directions, so that it formed four distinct spots. By October 12 the group had very greatly changed its appearance ; the chief bridge in the principal spot now entering it from the south, and cutting it across its length, and not, as before, in the direction of its length.

The group passed out of view at the west limb on October 17 and 18.

It returned again to the east limb on November 2, as a much broken and extended stream, divided into four distinct sections. Of these the two preceding sections broke up, like an exploding shell, into a great number of small faint spots ; and the two following sections coalesced to make one long and nearly continuous stream.

Although October 4 was the first appearance of the group, a short-lived spot marked the place where the great group was afterwards to appear, from September 10 to September 16. This spot, however, closed up and disappeared some days before reaching the west limb.

The Second or Smaller Southern Group appeared on the east limb on October 25. It consisted of a nearly continuous stream, which gradually broke up in its passage across the disc. The leading spot of the group reached the central meridian October 31, 10^h, and the entire group, which was about 10° of heliographic longitude in length, had passed by November 1, 4^h. The principal spot of the group was in heliographic latitude −20°·0, and longitude 296°·0. The position of its centre relative

to the central meridian of the Sun at the times when the magnetic disturbance began and ended, and when its most marked phases occurred, were as follows : the longitude of the central meridian at mean noon being 314°·0 on October 30, 300°·8 on October 31, and 287°·7 on November 1.

Magnetic Storm.	Greenwich Civil Time. d h m	Longitude of C.M. °	Longitude of Spot from C.M. °
Disturbance began	Oct. 31 6	304·1	8·1 E
Violent movements began ...	13	300·3	4·3
Most westerly declination ...	15 40	298·8	2·8
Most easterly declination ...	19	297 0	1·0
Violent movements ceased ...	23	294·8	1·2 W.
Disturbance ended	Nov. 1 5	291·5	4·5

The area of the group on October 31 was about 670 ; less than one-third that of the Great Southern Group.

The group as it passed towards the west limb took an arched form, convex to the solar equator, and the following portion of the group gradually closed up.

The group reached the west limb on November 6.

A third group of spots—one in the Northern hemisphere—was seen from October 2 to October 14, and returned to the east limb on October 29. It consisted at its first appearance of a large regular spot, followed by a stream of small spots. On its return it consisted chiefly of a pair of large regular spots. The mean longitude of the group on October 31 was 232° ; its latitude $17\frac{1}{2}$° N. ; its area 698. Its centre passed the central meridian about November 5, 18^h. It reached the west limb on November 11. A recognisable, but quite minor, magnetic disturbance took place on November 5.

The Magnetic Disturbances of 1903 *October* 12–13 *and October* 31–*November* 1.—The disturbance of October 12–13, although not falling within the category of "great" disturbance, presented many interesting and characteristic features. The limit of the disturbance period in the magnetic elements was comprised between October 12^d 18^h and 13^d 4^h, and the amplitude of declination disturbance amounted to 35′. The movements in Earth currents were especially marked between October 12^d 20^h and 13^d 3^h. The magnetic changes in this disturbance were of a bolder and more active character than those recorded in any similar disturbance during the preceding five years.

The disturbance of October 31–November 1 was of a far more important type. Commencing with characteristic suddenness at October 31^d 6^h, it speedily developed a phenomenal degree of activity, and from October 31^d 13^h to 23^h the movements of all the magnets were extremely violent ; changes exceeding one degree in arc in declination being frequently shown

in very short periods of time. The spots of light of the horizontal force and vertical force magnets passed beyond the range of the recording barrels for many hours during the afternoon and evening, and for shorter periods at other parts of the day, but little loss will be incurred on this account, as eye observations were made in great detail. Active disturbance ceased about November 1^{d} 5^{h}, the movements gradually subsiding after midnight. The declination magnet reached its extreme westerly position at October 31^{d} 15^{h} 40^{m} and its most easterly position at 31^{d} 19^{h}, the extent of change exceeding 2°.

This disturbance is greater than any recorded at the Royal Observatory since the great disturbance of 1882 November 17, which it closely resembled in many respects.

Royal Observatory, Greenwich:
1903 *November* 12.

Observations of Mars in 1903. By the Rev. T. E. R. Phillips, M.A.

The planet *Mars* was in opposition on 1903 March 28. His maximum diameter scarcely reached 14″·6, but the apparition was nevertheless a very favourable one for an examination of the planet's N. hemisphere. The latitude of the centre of the disc was +22°·6 at the time of opposition, and increased to over 25° by the middle of May. The weather, too, was on the whole very propitious, and the seeing conditions, despite some bad periods, frequently excellent. Between the middle of February and the end of May I was able to observe the planet on no fewer than sixty-six occasions. Thirty-two whole-disc drawings were made, besides drawings of special features. The instrument employed was a $9\frac{1}{4}$-inch silvered-glass reflector (mirror by With), with powers between 217 and 450.

The following is a description of the results obtained, the letters and numbers referring to the accompanying chart:—

The Maria.—The boundaries of the *Maria* were very well defined, and, in some cases, bordered by bright regions. As usual the *Maria* were by no means uniform in depth of tone, lighter and darker patches being frequently seen. The *Syrtis Major* (H) especially contained brighter areas—*Œnotria* (α'), *Iapygia* (β)—in its S. portion, but was very dark towards its N. extremity. The *Syrtis Minor* (G), *Sinus Sabæus* (I), *Margaritifer Sinus* (A), *Auroræ Sinus* (D), *Mare Acidalium* (B), and *Baltia* (C) were all noted as dark. *Mare Sirenum* (E), doubtless in consequence of its proximity to the limb, appeared less dark than usual. *Atlantis* separating it from *Mare Cimmerium* (F) was not

observed, though *Hesperia* (ϕ) was clearly seen. The large dusky area in the neighbourhood of the *Casius* (44) was very prominent, and contained two large dark spots or condensations.

The "Canals."—Several canals were seen with great distinctness. I have no doubt whatever as to the actual existence of many of them, though it is quite probable that at closer quarters they would appear much less regular. The theory that their appearance results from the unconscious joining together by the eye of projections from the *Maria* and dark spots does not satisfy the observations. The soft delicate lines or narrow streaks were frequently seen with great distinctness when no such prominent features were visible to account for them.

The interesting experiments described by Mr. E. W. Maunder and Mr. J. E. Evans in their paper published in *Monthly Notices* for 1903 June seem to me on careful consideration to suggest only a partial explanation of the canal system. They illustrate well what is very probably true—viz. that many of the reported canals are not really straight lines, but the impression produced on the retina by irregular markings, too faint and intricate to be clearly grasped. On the other hand there are canals so distinct and plain, under conditions of the very finest definition, as to preclude the idea that they are in any way subjective or imaginary.

A careful and systematic scrutiny of the planet reveals the noteworthy fact that the so-called "canal system" includes features of widely different nature and appearance. Dark and broadish bands, soft and delicate streaks with ill-defined condensations and spots, fine narrow dark lines, and the dusky edges of faint shadings and half-tones, are all termed "canals." It seems to me, therefore, that one hypothesis will neither explain them all, nor establish the contention that the canals generally are illusory.

The following is a list and description of the canals seen :

Agathodæmon (11). Dark and obvious.

Alcyonius (41). Not a separate canal, only the edge of dark shading of *Utopia*.

Amenthes (43). Distinct dusky line or narrow streak.

Astaboras (51). Glimpsed sometimes, but difficult.

Astusapes (50). Rather difficult.

Boreas (29). Rather dark. Very well seen on several occasions.

Boreosyrtis (49). Very dark and conspicuous. The region between this and the *Nilosyrtis* is lightly shaded.

Callirhoe (5). Very well seen as a soft streaky line.

Casius (44). Very large dark shading. In no sense canaliform.

Cephissus (42).* Broad and dark.

* By an error both the *Cephissus* and the *Marsyas* are numbered (42) on

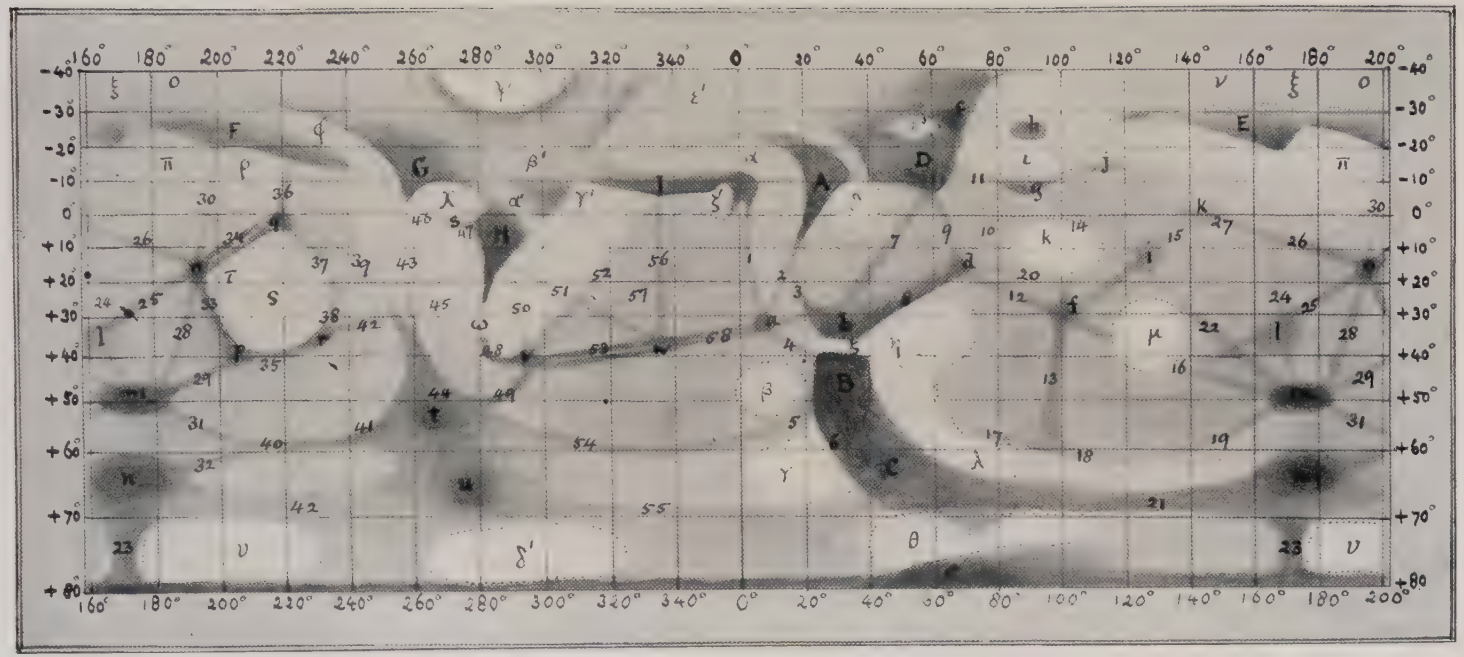

CHART OF MARKINGS ON MARS.

SEEN AT CROYDON ABOUT THE OPPOSITION OF 1903

REV T. E. R. PHILLIPS.

Ceraunius (13). Broad and rather diffuse.

Cerberus (34). Very dark and conspicuous. Straight and double, with shading between the two components. The doubling may possibly be an illusion, but it was distinctly apparent on several occasions with high powers and under the finest seeing conditions.

Chaos (35). Rather dark and sharply bounded to S.

Choaspes (32). Short broad streak connecting *Arsenius L.* with *Gyndes.*

Chrysorrhoas (10). Distinct and fairly easy.

Clarius (18). Fairly conspicuous, but soft.

Cyclops (36). Dark, rather broad, and very easy.

Deuteronilus (58). Rather dark and easy.

Erebus (25). Very readily seen on a good night. On April 22 it was noted as "dark, strong, and very obvious."

Eumenides (27). Faint and very difficult. Only a part seen.

Eunostos (37). Sharply bounded towards *Elysium.*

Euphrates (56). Beautifully soft, narrow streak. It seemed to terminate in *Ismenius L.* I was quite unable to trace its continuation in the *Arnon.*

Eurotas (19). Continuation of *Clarius.* Soft streaky line.

Ganges (9). Rather broad.

Gehon (1). Rather narrow, but soft.

Gigas (15). Very well seen as a soft and somewhat irregular streak, which at times gave the impression of consisting of hazy, ill-defined condensations and patches. The *Gigas* apparently starts from *Mareotis L.*, and not from the junction of *Ceraunius* (or *Iris*) and *Uranius.*

Granicus (31). Distinctly seen connecting the W. end of *Propontis* with the *Gyndes* and *Choaspes.*

Gyndes (40). Broad and dark streak.

Hades (28). Rather dark and conspicuous.

Hyblæus (38). Very much plainer than at recent oppositions. Dark and sharply bounded towards *Elysium.*

Indus (3). Distinct and fairly dark. The area included by *Indus*, *Oxus*, *Jordanis*, and E. end of *Achillis Pons* is shaded.

Iris (14). Well seen as a narrow continuation of *Ceraunius.*

Jamuna (7). Soft shading, but seen very distinctly on May 7.

Jaxartes (6). Not seen as a canal. The p. edge of *Mare Acidalium.*

Jordanis (4). Seen very distinctly connecting *Siloe Fons* with *Mare Acidalium.*

Læstrygon (30). Rather narrow, but not difficult.

Magnes (23). Dark and conspicuous feature connecting p. end of *Arsenius L.* with dark shading round polar cap, and forming E. boundary of elliptical white area.

Marsyas (42).* Frequently seen connecting *Morpheos L.* with the *Pactolus.*

the chart. The *Cephissus* is the broad band connecting *Arsenius L.* with the unnamed spot (*u*). The *Marsyas* extends W. from *Morpheos L.*

Nepenthes (47). Short and dark, swelling out into *Mœris L.*

Nilokeras (8). Quite dark and sharply bounded on N. edge. Soft and diffuse to S. In previous apparitions this canal has appeared "anomalously" double.

Nilosyrtis (48). Dark curved line, frequently seeming separated from the tip of *Syrtis Major*.

Nilus (12). Rather conspicuous, but soft and streaky.

Orcus (26). Faint and difficult.

Oxus (2). Narrow and sharp near *Margaritifer Sinus*, but becoming more diffuse towards *Siloe Fons*.

Pactolus (39). Seen frequently as a curved narrow streak connecting *Pambotis L.* with the *Casius*.

Pallas (46). Probably illusory. Only the edge of shading round *Libya*.

Phison (52). Appeared to be the dusky edge of orange tone of disc.

Phlegethon (16). Interrupted by white area central at about $\omega = 128°$, $\phi = +35°$.

Pierius (54). Dark and conspicuous streak.

Protonilus (53). Very dark and prominent. Appeared distinctly double on May 12 with Dr. Kibbler's $12\frac{1}{2}$-inch reflector at Stamford Hill, and also on May 14 with my own instrument.

Pyriphlegethon (22). Broad and diffuse.

Sitacus (57). Very narrow, dark, curved line. Note on May 14: "Wonderfully distinct this apparition."

Styx (33). Dark and sharply defined on its W. side by the bright region of *Elysium*. Soft and diffuse on E. side. All the region included by the *Hades*, *Boreas*, and *Styx* appeared at times lightly shaded.

Tanais (17). Only a trace seen. The brightness of *Nerigos* (λ) seemed to unite with that of the region W. of *Achillis Pons* and obliterate completely the p. end of *Tanais*.

Thoth (45). Fine narrow line.

Titan (24). Soft, diffuse, and difficult. Not traced beyond the *Orcus*.

Uranius (20). Seen a few times, but rather ill-defined.

A broad streak (21) was seen connecting *Arsenius L.* (*n*) with the shaded region of *Baltia* (C.).

Another rather faint dusky streak (55) was found running from about $\omega = 290° + 70°$ to the E. side of *Baltia* (C.).

On March 10 and 11, and again on April 17, there appeared to be a "new" canal running from the bend of *Nilosyrtis* ($\omega = 232°$, $\phi = +38°$) towards the *Syrtis Minor*. Subsequently this feature could not be recovered, though on April 19 the *Thoth* was seen with great distinctness.

The "Lakes."—The following were observed:

Arsenius L. (*n*). Very large and dark spot about 14° N. of *Propontis*.

Coloe Palus (*v*). Very conspicuous spot at end of *Nilosyrtis*.

Copais Palus (*t*). Very dark and conspicuous spot.

Hecates L. (*p*). A conspicuous object.

Hyperboreus L. (*e*). Very dark and large swelling on band surrounding polar cap.

Ismenius L. (*w*). Well defined and conspicuous spot. Appeared double on May 12 and 14, when the *Protonilus* was also doubled.

Lunæ L. (*d*). Fairly dark and conspicuous.

Mareotis L. (*f*) Quite a dark spot on *Ceraunius* at meeting of this canal with *Nilus*, *Phlegethon*, and *Gigas*.

Mœris L. (*s*). Dark swelling on *Nepenthes*.

Morpheos L. (*r*). Not very large, but easily seen. At junction of *Chaos*, *Hyblæus*, and *Marsyas*.

Nectaris Fons (*c*). Very dark spot seen on May 7, W. of *Protei Regio* (ϵ), near the mouth of *Nectar*.

Niliacus L. (*b*). Sharply bounded by *Achillis Pons*, but soft and diffuse to S.

Nodus Gordii (*i*). A dusky, ill-defined shading about the junction of *Pyriphlegethon* and *Gigas*.

Pambotis L. (*q*). Seen well at times at junction of *Cyclops* and *Cerberus*.

Phœnicis L. (*j*). Dusky spot seen a few times near extremity of *Pyriphlegethon*.

Phrygius L. (*k*). Faint dusky spot at the junction of *Gigas* and *Eumenides*. This appears identical with the *Nodus Gordii* of Lowell.

Propontis (*m*). Much elongated and very dark spot. Appeared almost rectangular at times.

Siloe Fons (*a*). Rather small, but well defined.

Solis L. (*h*). Dark and very well seen, despite its proximity to the limb.

Tithonius L. (*g*). A dark and conspicuous marking.

Trivium Charontis (*o*). Not quite so large as at some oppositions, but very conspicuous.

A large, ill-defined dusky shading (*l*) was seen about the junction of *Erebus* and *Titan* ($\omega = 168°$, $\phi = +35°$).

Another dark and large spot (*u*) was noted at about $\omega = 277°$, $\phi = +66°$. Is this a new feature?

White Regions and Bright Spots.—These furnished the special feature of *Mars* during the past apparition. As usual, some of the borders of the *Maria* and regions near the limb appeared intensely white. Thus *Elysium* (ς), *Libya* (χ), *Hellas* (ψ), the region *f Syrtis Major* and *Pharos Insula* (γ'), *Edom Promontorium* (ς'), *Deucalionis Regio* (α), the S. part of *Chryse* (δ), *Thaumasia* (ι), and the regions of *Phœthontis* (ν), *Electris* (ξ), *Eridania* (o), and *Noachis* (ϵ'), foreshortened at the S. limb, all appeared very bright; *Zephyria* (π) and *Æolis* (ρ) also appeared so at the end of May; but the features demanding special notice

were : the E. part of *Elysium* (τ), brilliant spots on *Cydonia* (β) and *Ortygia* (γ), another (η) W. of *Achillis Pons* (ζ) which appeared to extend along the coast of *Acidalium Mare* and *Baltia*, two very brilliant regions whose centres were approximately (κ) at $\omega = 100°$, $\delta = +10°$, and (μ) at $\omega = 128°$, $\delta = +35°$ respectively, and three well-defined bright areas adjoining the dark line bounding the N. polar cap. These latter will be described in the paragraph dealing with the N. polar regions.

As often remarked, the white regions of *Mars* appear much more intense at the limb than near the centre of the disc. A spot comparable with the polar snows in brightness when in the former position (in some instances) fades so as to be distinguishable with difficulty on the central meridian.

During the past apparition the white areas above mentioned were, on the whole, pretty constant in position. Mr. Denning, however (*Monthly Notices* for 1903, June), detected on May 21 a bright band (as of cloud) separating the *Syrtis Major* (H) from the dark regions further S., which by the 23rd had diffused itself over the *Syrtis*, dimming its outlines and making it much paler. On May 22 *Libya* (χ) appeared to me intensely white, but definition about this time was very bad at Croydon and fine details obliterated. On May 24 I noticed that the region of *Zephyria* (π) and *Æolis* (ρ) N. of *Cimmerium Mare* was also whitened, an observation which accords very well with Mr. Denning's notes on the 25th. The *Syrtis Major* was now very faint, but at the time I made no special comment on the fact, attributing it to the bad atmospheric conditions prevailing. Mr. Denning's observations, however, make it clear that about this time a large cloud area drifted over this region of the planet and produced the interesting changes described.

As during the two previous apparitions, it frequently appeared as if a band of cloud or mist (ω) severed the *Nilosyrtis* from the *Syrtis Major*, but I was often unable quite to satisfy myself that the severance was complete.

Achillis Pons (ς) was quite conspicuous, though at times it appeared lightly shaded at its eastern end. It was certainly much less bright than the region (θ) between *Baltia* and *Hyperboreus L.*

North Polar Regions. — The region N. of latitude + 70° generally appeared considerably lighter in tone than the centre of the disc, and was usually bounded by a dusky streak. The polar cap itself, after being clear in February, seemed to become enveloped in fog (?) at the beginning of March. The following entries referring to this feature were made in my note-book :

March 5. "There appeared to be a certain amount of fog surrounding the snow cap, the latter itself in the moments of better definition appearing quite small. This fog was also suspected on March 1 and 3."

March 7. "There appears to be much fog round the N. Pole, and I don't think the snow itself was glimpsed at all."

March 8. "Large patch at N. Pole, but the snow could be seen at times flashing out with dazzling whiteness."

March 10. "The fog (?) at the N. Pole appears to be diminishing."

March 14. "All trace of fog seems to have left the polar regions. The snow cap was seen now and then in moments of superb definition to be quite definite and bounded by a very narrow dark line, with a somewhat similar but less bright region adjoining it at about $\omega = 220°$."

Of the three bright areas in the N. polar regions, that just mentioned (υ) was the first to be observed; subsequent observations seemed to place its centre at a little over 200° of longitude. It was frequently a conspicuous object, and towards the end of April was found to be sharply bounded at its p. side by the canal *Magnes*.

On March 31 I noticed an intensely bright streak (θ) severing *Baltia* from the dark shading round the polar snow. On April 29 and May 1 the p. end of this region was comparable with the cap itself in brightness, but *f* this bright nucleus there seemed to be a dusky projection from *Baltia* extending towards *Hyperboreus L.* This projection, however, was not subsequently observed.

A third very brilliant region (δ') was detected on May 14 adjoining the polar snow cap. It was again seen on May 15 and 19, and the longitude found to be about 295°.

After the disappearance of the fog or mist in the early part of March the snow cap was seen to be bounded by an intensely dark line. This line was quite narrow in most longitudes, but at the end of March it was found greatly swollen at about $\omega = 60°$. This swelling, which on April 24 seemed to indent the snow cap, is doubtless identical with *Hyperboreus L.* of Schiaparelli. It was intensely dark against the snow, but appeared to shade off gradually in an *s f* direction.

At the time of opposition the season of the planet's N. hemisphere was a little past midsummer, and the polar cap was quite small. It seemed to diminish but very slowly subsequently, the minimum diameter (observed in May) being estimated at about 10° or 12°. The snow at times shone with a slightly bluish tinge.

To sum up the results of my observations, a careful and systematic scrutiny of the planet during the past four apparitions has revealed to me the following facts:

(1) Changes, partly due to seasonal influences and the appearance of clouds or mists, and partly real, unquestionably occur from time to time in the details of the surface configuration.

(2) The main results of Professor Schiaparelli's work are imperishable and beyond question. During recent years some

observers have given to the so-called "canals" a hardness and an artificiality which they do not possess, with the result that discredit has been brought upon the whole canal system. No doubt the time has come when a distinction must be made between what is real on *Mars* and what is subjective or illusory, but of the substantial accuracy and truthfulness (as a basis on which to work) of the planet's configuration as charted by the great Italian in 1877 and subsequent years, there is, in my mind, no doubt.

(3) Contrast, as has been so ably pointed out by M. E. M. Antoniadi, is doubtless accountable for very many of the extraordinary appearances observed on the planet. Not a few of the canals are now seen to be the intensified edges of faint tones in accordance with the late Mr. Green's suggestion, while M. Antoniadi's explanation of the phenomena of gemination as due to the same effect of contrast appears both simple and satisfactory.

Observations of White Spots on Saturn in 1903.

By A. Stanley Williams.

The visibility of a bright spot on *Saturn* was announced by Professor E. E. Barnard on June 24 of the present year. Unfortunately I had just left England for Ireland, so that, although Professor Kreutz kindly sent me a postcard announcing the discovery, it was only on my return home towards the end of July that I heard of the existence of the spot, and was able to make any observations of the planet. At that time the probable position of the spot detected by Barnard was quite unknown, so that I confined my attention simply to observing the transits of any spots that might happen to be visible, purposely avoiding any attempt at comparing the observations, or to identify them with the spot referred to, in order that the observations might not be biassed thereby.

The observations recorded below all relate to white spots * situated in a bright zone lying to the north of a broad dark band on the north side of the bright equatorial zone. The former bright zone is hereafter termed the N. temperate zone. The broad dark band between it and the equatorial zone has been called the N. equatorial belt It is actually coarsely double, consisting of two dark bands separated by an ill-defined lighter interval, not so bright or definite as either the equatorial zone or the N. temperate zone. The telescope used was a $6\frac{1}{2}$-inch reflector, a power of 225 being always employed. At first great

* I have called the spots *white* spots for distinction, but they have usually appeared to me to be distinctly yellowish.

difficulty was experienced in observing the transits of the spots with any satisfaction owing to the observer being out of practice, and consequently the earlier observations are usually less satisfactory than the later ones. The weather, moreover, proved most unfavourable, and this, combined with the low altitude of the planet, formed a serious obstacle to obtaining satisfactory results. The observations that I have been able to obtain are therefore comparatively few in number, and not so accurate as I could have wished. For this reason I have not attempted to make any discussion of the results, or any identification of the spots observed, of which, however, it is evident that there must be several. Since, however, these observations may be of value in conjunction with those of other observers for determining the rotation period of the surface material in this latitude of *Saturn*, the full details of them are given below :—

1903 July 24, $11^h\ 34^m$ (G.M.T.) White spot transited. Weight (on a scale ranging from 1, bad, to 5, good)=1. Time very uncertain owing to definition being very unsteady, though the spot itself was certain. When first seen, $\frac{1}{4}^h$ earlier, it was some distance E. of the central meridian of the disc. Once the spot seemed to be double east and west.

July 31, $10^h\ 50^m$. A plain white spot visible about $\frac{1}{2}^h$ before transit. The following *estimated transits** were observed :— $13^h\ 33^m - 12^m = 13^h\ 21^m$; $13^h\ 41^m - 20^m = 13^h\ 21^m$. Both were rough estimates owing to the image being dim from cloud.

August 3, $11^h\ 18^m$. A plain, round, well-defined spot transited. W. = 2. The following estimated transits were also observed :—$11^h\ 07^m + 23^m = 11^h\ 30^m$ (good) ; $11^h\ 13^m + 07^m = 11^h\ 20^m$ (good) ; $11^h\ 29^m - 12^m = 11^h\ 17^m$ (fair) ; $11^h\ 37^m - 22^m = 11^h\ 15^m$ (good).

August 13, $10^h\ 24^m$. Small, rather well-defined white spot estimated 10^m past transit, which therefore occurred at $10^h\ 14^m$.

August 22, $11^h\ 03^m$. Small, rather faint, inconspicuous spot transited. W.=1. It seemed, however, to be pretty well defined. The following estimated transits were also made :— $10^h\ 55^m + 8^m = 11^h\ 03^m$; $11^h\ 13^m - 7^m = 11^h\ 05^m$; $11^h\ 16^m - 12^m = 11^h\ 04^m$; $11^h\ 18^m - 15^m = 11^h\ 03^m$ (widely past transit).

September 1, $9^h\ 20^m$. Very bright and plain spot transited. W. = 1, very rough owing to poor seeing. The following estimated transits were also observed :—$9^h\ 13^m + 12^m = 9^h\ 25^m$; $9^h\ 29^m - 7^m = 9^h\ 22^m$ (distinctly past transit, but only slightly so) ; $9^h\ 34^m - 10^m = 9^h\ 24^m$. Note added September 2 : "For a long distance preceding this spot the N. temp. zone was very bright and luminous looking."

September 3, $8^h\ 47^m$. A remarkably plain, bright, and definite spot transited. Definition good, but cloud came up, so that the above time is only very approximate.

September 5, $9^h\ 43^m$. A rather well-defined spot estimated

* See *Monthly Notices*, vol. liv. p. 298.

20^m past * transit, which therefore occurred at $9^h\ 23^m$. Following this spot the N. equat. belt seemed broader than usual, so as to encroach on the N. temp. zone, which latter was narrow and faint, with one or two small faint spots following the central meridian. On the same date the following estimated transits were made of a small and difficult spot :—$10^h\ 26^m + 30^m = 10^h\ 56^m$; $10^h\ 46^m + 25^m = 11^h\ 12^m$ (very rough); $10^h\ 52^m + 17^m = 11^h\ 09^m$ (very rough).

September 7. The following estimated transits of a rather bright and not difficult spot were observed :—$8^h\ 46^m - 15^m = 8^h\ 31^m$ (fair obs.); $8^h\ 54^m - 25^m = 8^h\ 29^m$ (rough estimate owing to frequent clouds).

September 9, $9^h\ 08^m$. An apparently pretty plain spot transited, but seeing very indifferent. W. = 1. Same date, $10^h\ 41^m$. A well-defined and fairly bright spot transited. W. = 2. The following estimated transits were also observed :—$10^h\ 32^m + 10^m = 10^h\ 42^m$ (good); $10^h\ 52^m$, the spot seemed distinctly past transit, but seeing very confused. The spot appeared to be rather a bright one for a *Saturn* spot.

September 13, $8^h\ 50^m$. A bright, plain white spot transited. W. = 2. The following estimated transits were also observed :—$8^h\ 34^m + 13^m = 8^h\ 47^m$ (good); $9^h\ 04^m - 20^m = 8^h\ 44^m$ (good). Same date, $10^h\ 24^m$; a white spot transited. W. = 2. Spot difficult to observe owing to indifferent seeing. It was strongly suspected to be double east and west. The following estimated transits were also observed :—$10^h\ 08^m + 16^m = 10^h\ 24^m$ (poor obs.); $10^h\ 11^m + 12^m = 10^h\ 23^m$ (fair); $10^h\ 17^m + 5^m = 10^h\ 22^m$ (fair); $10^h\ 33^m - 8^m = 10^h\ 25^m$ (poor estimate).†

September 14, $9^h\ 59^m$. White spot estimated 12^m past transit, which therefore occurred at $9^h\ 47^m$. Seeing very poor and spot difficult to observe.

September 17, $10^h\ 07^m$. A rather small but bright, well-defined, and nearly round spot transited. W. = 2. The following estimated transits were also made :—$9^h\ 57^m + 10^m = 10^h\ 07^m$ (good); $10^h\ 14^m - 8^m = 10^h\ 06^m$ (good).

September 22. The following estimated transits were observed of a rather bright and pretty large spot, which was not at all difficult :—$9^h\ 16^m - 10^m = 9^h\ 06^m$ (good); $9^h\ 22^m - 15^m = 9^h\ 07^m$ (indifferent); $9^h\ 24^m - 20^m = 9^h\ 04^m$ (fair). At $9^h\ 36^m$ another white spot transited. W. = 1. This spot was very small and inconspicuous, and much more difficult than the previous one, though it seemed to be well defined. The following estimated transits were also observed :—$9^h\ 22^m + 10^m = 9^h\ 32^m$ (rough); $9^h\ 24^m + 12^m = 9^h\ 36^m$ (fair).

* The observation is actually entered as 20^m *before* transit, but it is pretty certain that the spot must have been past transit from the note that follows.

† The two observations of September 13 are not quite independent, as the observer had a rough recollection of his observations of September 9, when probably the same spots were observed, assuming a rotation period of about $10^h\ 38^m$.

September 23, $9^h\ 21^m$. Small, faint, inconspicuous spot transited. W. = 1. Some very sharp views of *Saturn* were obtained on this night, but there were no *conspicuous* white spots in sight. The N. temp. zone seemed to be very narrow in this part of the planet.

In the following table I have brought together all the observed transits of spots in the N. temp. zone. The concluded times of transit are what seem to me to be the most probable times according to the foregoing observations. The relative degrees of accuracy are indicated in the third column. With reference to observations of this kind, made under such unfavourable conditions, it should be mentioned that it is very difficult for an observer to avoid being biassed in his subsequent estimates by his first view of a spot. I have tried hard to avoid being thus biassed, but cannot hope to have escaped this influence altogether. The trouble is that in trying to struggle against the influence of such a first impression one is apt to err in the opposite direction.

Concluded Transits of White Spots on Saturn.

Date.	G.M.T. of Transit. h m	Weight.	Notes.
1903 July 24	11 34	1	Perhaps double.
31	13 21	1	Plain spot.
Aug. 3	11 19	4	Plain, round, well defined.
13	10 14	1	Small, rather well defined.
22	11 03·5	2	Faint, inconspicuous.
Sept. 1	9 22	2	Very bright and plain.
3	8 47	1	Remarkably plain and bright.
5	9 23	1	Rather well defined.
5	11 05	1	Small, difficult.
7	8 30	1	Rather bright, not difficult.
9	9 08	1	
9	10 41	3	Rather bright.
13	8 48	3	Plain and bright.
13	10 24	3	Suspected double.
14	9 47	1	
17	10 07	3	Small, bright, nearly round, well defined.
22	9 06	1	Pretty large, rather bright.
22	9 35	2	Very small.
23	9 21	1	Small and faint.

It remains to add a few words on the appearance of the spots. Generally speaking, the N. temperate zone was extremely brilliant, but it was very irregularly bright. In some parts of the

planet it was exceedingly bright and luminous looking, whilst in other places it was comparatively dull and lustreless. The spots constituted the brightest regions of this irregularly luminous zone. They were frequently indefinite, particularly in an east and west direction, so that it was often difficult to locate their position satisfactorily, or even to fix upon anything sufficiently definite to observe the transit of. They also sometimes gave the impression of being double in an east and west direction, though it was difficult to be sure of this in the unsteady definition almost always prevailing at so low an altitude. The unsteady seeing formed, I think, the chief obstacle to making good observations. Under more favourable conditions I believe the spots would have been plain and easy objects. Too much value should not be placed upon the descriptions of the spots in the notes, as their visibility would no doubt be greatly affected by the unfavourable conditions of the seeing, so that the same spot might be described as being plain and relatively bright on one night, and only as faint and inconspicuous on another night, without any real change in brightness or appearance being necessarily implied thereby, the difference arising merely from the circumstance that on one of the nights the bad seeing did not permit the spot to be seen so clearly as on the other.

In general appearance these N. temperate spots had considerable resemblance to the white spots which I observed about ten years ago in the equatorial zone,* but the latter spots were probably not quite so bright and luminous looking as the former.† During the course of the recent observations I have on several occasions examined the equatorial zone. It appeared remarkably white, whiter than the N. temperate zone, and there were faint but distinct indications of brighter spots in it, though compared with the last-mentioned zone it was very uniform in brightness. Owing to the unfavourable position of *Saturn* no systematic observation of these equatorial spots was attempted. On August 13, however, a faint spot was observed to transit at $10^h\ 43^m$. Also on August 21 a comparatively bright and conspicuous spot was visible in the equatorial zone. At $10^h\ 0^m$ it was estimated to be 13^m before transit, but owing to cloud the transit could not be directly observed. The spot, which was well defined, seemed to be divided into two by a narrow, faint, dark belt in the equatorial zone, probably the same belt as that which used to be known as the "equatorial mottled belt."

* See *Monthly Notices*, vol. liv. p. 309, and vol. lv. p. 361.

† During the past two or three months the equatorial spots have certainly been decidedly fainter and more difficult than the N. temp. spots.

20 *Hove Park Villas, Hove:*
1903 *October* 13.

Observations of Borrelly's Comet (*c* 1903) *made at the Natal Observatory, Durban.*

(*Communicated by E. Nevill.*)

The following observations were made by Mr. Rendell by means of a cross-bar micrometer with the equatorial refractor, aperture 8 inches, focal length 10 feet, magnifying power 50.

Date. 1903	Greenwich Mean Time.	Apparent Difference Comet—Star. R.A.	N.P.D.	Comet's Approx. Hour-angle East.	No. of Comparisons.	Comparison Star.
	h m s	m s	′ ″	h m		
June 24	9 3 53	+0 39·32	−5 2·1	4 35	7	*a*
25	9 5 11	+0 12·87	−5 54·6	4 29	9	*b*
27	8 53 28	+2 1·11	−2 36·0	4 30	5	*c*
28	9 0 25	+0 7·10	+2 15·7	4 18	5	*d*
July 2	9 9 48	−0 11·37	−5 32·4	3 44	7	*e*

Comparison Stars.

		h m s	° ′ ″	
a	B.D.−5° No. 5663	R.A. 21 47 10·8	N.P.D. 95 57·0	(1855·0)
b	B.D.−4° No. 5568	21 46 35·9	94 57·2	(„)
c	B.D.−2° No. 5643	21 42 21·9	92 38·6	(„)
d	Anon. (Mag. 8)	21 43	91 17	(„)
e	7 Pegasi	21 35 45·16	84 54 39·2	(1870·0)

[Star *b* = Radcliffe 5900 = Piazzi XXI. 320.]

Notes.

June 24. The star B.D.−5° No. 5664, mag. 9·9, closely preceded the Comet, the star being a little to the north. Nucleus of Comet apparently about same mag. as this star. Nebulosity about 10′ in diameter surrounded nucleus. Central condensation, with radius about 1′, considerable. Comet a conspicuous object in the 3-inch finder.

June 25. Sky misty, but central condensation well seen. Nebulosity more extended, but nucleus less stellar than yesterday.

June 26. Comet brighter. Sky misty and cloudy. Dense central condensation seen, but stellar nucleus not visible. Estimated place of Comet at $8^h\ 45^m$ G.M.T. = R.A. $21^h\ 45^m{\cdot}6$, N.P.D. 93° 45′ (1855). Comet's Hour-angle East = about $4^h\ 43^m$. Extension of tail suspected in s.p. direction.

June 27.—Nebulosity similar to June 26. Stellar nucleus appears about = 10 mag. At $9^h\ 15^m$ G.M.T. a faint star was involved in the dense part of the central portion of the Comet, and could not be distinguished from the nucleus.

June 28.—Nebulosity most extended in s.p. direction.

July 1. At $8^h\ 40^m$ G.M.T. a very faint star preceded the Comet on the north. Nucleus seen, but not stellar. Tail (surrounding nucleus equally in all directions) very faint and diffused.

July 2. Nucleus not stellar. Faint extension of tail considerable. Sky misty.

Note "On the Positions of 166 Stars around Nova Geminorum" &c. By F. A. Bellamy.

In a letter received from Father Hagen he states that he has satisfied himself that the two stars Nos. 57 and 58, referred to in *Monthly Notices*, lxiii. p. 520, are Oxford 158 and 17 respectively. In the Georgetown College Observatory Circular for Nova *Geminorum* the figures on page 4 for $\Delta\delta$ for Nos. 57 and 58 had been partly interchanged; they should be $+9''.4$ and $-1''.7$ instead of $+1''.4$ and $-9''.7$; the chart is correct. The Hagen number for Oxford 37 should be 27; the figure 2 had dropped out after passing the proof sheet. Further, he identifies Oxford 151 as Hagen 72.

University Observatory, Oxford:
1903 *October* 21.

Measures of Southern Double Stars made at Shanghai, 1902–1903. By James L. Scott.

The following measures of southern doubles were made with the same 5-inch refractor as those published in vol. lix. of the *Monthly Notices*. Bright wire illumination was used throughout, and nearly all the stars were measured within an hour of the meridian.

Star's Name.	R.A.	S. Dec.	P.A.	Dist.	No. of Nights.	Mags.	Date.
	h m	° ′	° ′	″			
O.S. 51	0 3	14 51	108 4	10·1	2	9, 9	1902·850
β 391 (κ^1 Sculptoris)	0 4	28 32	272 8	1·10	2	6·5, 6·5	·847
h 3377	0 28	26 38	58 1	19·1	2	6, 9·5	·854
h 3375	0 29	35 32	166 9	6·05	2	6·5, 9·4	1903·003
h 3395	0 41	42 27	76 4	7·40	3	8·5, 9	1902·854
C.G.C. 784 ...	0 47	23 9	268 5	2·15	2	7·5, 8	1903·008
Washington I. ...	0 48	25 19	12 7	5·70	2	6·7, 8·5	1902·850
C.G.C. 815 ...	0 48	25 31	27 0	13·2	1	7, 7·4	·852
LL. 1662... ...	0 53	16 13	215 2	6·31	2	8, 8·4	·882
Cord. Z.C. 1^h, 333	1 14	27 2	312 0	2·05	2	8, 8·5	·854
h 2036	1 15	16 20	15 1	1·50	3	7, 7·3	·862
h 3447 (τ Sculptoris)	1 32	30 25	97 0	1·80	3	6, 7	·901
h 3461	1 41	25 33	53 7	4·70	3	5, 9·3	·901
292 Ceti	1 54	23 24	305 0	8·44	1	7, 7·4	·895
Hastings I. ...	2 11	18 42	353 6	2·05	3	8, 8·5	1902·906

Star's Name.	R.A. h m	S. Dec. ° ′	P.A. ° ′	Dist. ″	No. of Nights.	Mags.	Date.
C.G.C. 2739 ...	2 30	21 59	97 8	14·7	1	7·3, 9	1902·912
h 3527	2 40	40 58	44 1	2·01	2	7, 7	·931
h 3532	2 45	37 50	147 1	5·40	2	6·8, 8·5	·939
β 741	2 53	25 22	167 7	1·48	3	8, 8·4	·939
h 3565	3 14	18 55	115 2	6·24	2	5·8, 8·5	·950
h 3596	3 45	32 5	135 9	8·02	2	8, 8·3	·964
f Eridani ...	3 45	37 56	205 4	7·40	2	5, 5·5	·964
β 1004	3 58	34 46	141 2	1·90	3	7·3, 7·8	·983
β 184	4 23	21 43	259 9	1·25	2	7, 8	1903·137
h 3750	5 16	21 20	280 1	3·50	2	4·8, 9·5	·137
h 3752	5 18	24 53	101 4	3·05	2	5·5, 7·5	·137
β 757	7 9	36 22	69 5	3·01	2	6·5, 9·4	·162
Jacob 4	7 15	36 35	209 6	2·90	2	9·8, 10	·162
h 3950	7 15	21 52	345 4	4·14	2	8·3, 8·3	·162
h 3949	7 15	30 37	77 8	2·98	2	8, 8·4	·162
Σ 1104	7 24	14 47	332 7	2·35	2	7, 9	·162
P. VII., 124 ...	7 25	31 38	52 0	8·60	1	6·5, 7·5	·164
σ Argûs	7 26	43 6	74 2	22·3	1	3, 9	·164
Howe 8	7 49	34 27	280 1	2·58	2	5, 9	·162
Σ 1157	7 49	2 32	245 9	1·20	2	8, 8	·260
β 583	8 4	6 25	69 8	1·75	2	9, 9·5	·167
β 334	8 4	21 51	352 4	2·80	2	8, 9	·167
O.S. (O.A. 8124)	8 5	26 50	261 2	3·30	2	8·5, 9·3	·162
h 4063	8 11	37 0	349 3	18·1	1	7·5, 9·3	·260
β 454	8 12	30 37	15 6	2·50	2	6·8, 9	·293
h 4093	8 23	38 43	122 9	8·05	2	7, 7·5	·260
Σ 1295	8 51	7 35	359 2	4·30	2	7, 7·3	·290
β 210	8 52	17 3	183 6	2·70	2	7, 7	·293
C.G.C. 12,339 ...	8 58	33 7	153 0	13·7	1	7·3, 7·8	·293
Σ 1316 (A–C) ...	9 2	6 44	169 4	7·50	2	8, 10	·290
h 4200	9 16	31 20	72 8	2·59	2	7·8, 8·5	·337
ζ Antliæ	9 26	31 27	212 5	8·00	1	5·8, 6·5	·290
h 4224	9 32	30 47	117 5	7·01	2	8, 9	·337
h 4249	9 44	34 33	126 5	4·16	2	8, 8	·337
C.G.C. 13,722 ...	9 58	17 30	273 6	21·6	1	6·5, 7·4	·337
β 217	10 2	24 14	279 4	1·95	2	8, 8	·337
β 25	10 17	9 16	174 3	1·80	2	8·3, 8·8	·348
s Velorum ...	10 28	44 31	217 4	13·3	1	6·5, 6·8	·337
Σ 1474	10 43	14 44	196 5	6·77	2	6·7, 7	1903·293

Star's Name.	R.A.	S. Dec.	P.A.	Dist.	No. of Nights.	Mags.	Date.
	h m	° ′	° ′	″			
Σ 1476	10 44	3 29	2 3	2·54	2	7, 8	1903·348
LL. 21,178 ...	10 57	15 9	16 2	2·90	2	8, 8·5	·364
Howe 15 ...	10 58	26 58	335 2	2·10	2	7·5, 9·3	·348
h 4423	11 12	45 20	275 2	2·20	3	7, 7·3	·348
Jacòb 7	11 25	23 55	78 3	8·51	2	6, 8·5	·348
N. Hydræ ...	11 27	28 43	209 5	9·24	2	5·5, 5·5	·293
h 4455	11 32	33 10	243 7	3·83	2	6·3, 9·4	·293
C.G.C. 15,942 ...	11 34	37 25	95 7	16·8	1	7, 9	·337
Howe 16 ...	11 35	36 52	103 6	3·31	2	8, 8·5	·364
β Hydræ ...	11 48	33 21	352 6	1·76	3	5, 6·5	·348
h 4481	11 52	21 59	197 4	3·25	2	8, 8	·389
h 4495	12 0	32 23	318 1	6·58	1	6·5, 9	·389
C.G.C. 16,612 ...	12 3	34 0	202 7	3·86	2	6·5, 9	·348
Jacob 8	12 5	34 8	20 5	3·07	2	6·5, 8·8	·364
LL. 22,863 ...	12 6	16 14	285 4	6·07	2	6·5, 9	·348
D Centauri ...	12 9	45 10	241 5	3·10	2	5·5, 7	·397
δ Corvi	12 25	15 57	214 3	24·40	1	3, 8·5	·389
γ Virginis ...	12 37	0 54	330 1	5·88	3	3, 3	·397
h 4556	12 49	27 25	81 9	6·41	1	7, 8·5	·397
γ 4563	12 55	33 5	236 7	6·80	2	7·5, 9	·364
β 342	13 10	18 23	33 8	3·96	3	8, 8·5	·457
O.A. 12,867 ...	13 21	22 43	356 2	1·60	2	8·8, 9	·457
β 114	13 29	8 6	142 8	1·50	2	8, 8	·449
h 4608	13 36	33 28	178 6	4·52	1	7·5, 7·5	·397
h 4617	13 45	29 22	260 2	5·02	2	7·5, 9·5	·457
κ Centauri ...	13 46	32 30	109 5	7·91	1	4·8, 6	·457
β 343	13 46	31 7	120 7	1·02	3	6, 7	·457
Lac. 5751 ...	13 48	31 36	3 8	14·32	1	7, 8·5	·485
Σ 1788	13 49	7 34	79 5	2·70	2	6·8, 8·5	·444
h 4661	14 6	28 51	228 7	4·50	1	9, 9	·485
Howe 28 ...	14 12	27 3	119 7	3·20	2	9·3, 9·3	·449
h 4672	14 14	42 36	304 0	4·00	2	6·5, 9·5	·449
Σ 1837	14 19	11 13	300 5	1·42	2	7, 8·5	·449
β 117	14 26	15 11	95 9	2·30	2	8, 9	·485
h 4690	14 31	45 41	25 6	19·2	1	5·5, 8	·485
Howe 29	14 31	37 6	213 6	4·20	2	8, 8·5	·512
54 Hydræ ...	14 40	25 1	130 0	8·70	1	5·5, 7·5	·512
β 106 (A – B) ...	14 44	13 44	342 1	1·80	2	5·5, 6·5	·449
β 347 (A – C) ...	14 48	32 5 3	242 7	58·1	1	6, 9·8	1903·485

Star's Name.	R.A.	S. Dec.	P.A.	Dist.	No. of Nights.	Mags.	Date.
	h m	° ′	° ′	″			
h 4718	14 51	34 58	63 3	2·20	2	7, 9	1903·457
P. XIV., 212 ...	14 52	20 57	294 9	16·76	2	6, 8	·449
h 4722	14 53	30 18	339 8	8·70	2	7·5, 9	·512
h 4727	14 57	27 26	36 8	7·62	2	8·3, 8·3	·485
Howe 31 ...	15 7	36 52	46 4	6·50	2	7·2, 7·5	·496
Anon.	15 10	36 45	197 7	20·7	1	7, 7·5	·496
β 227	15 13	23 54	175 1	2·10	2	7, 8·5	·496
h 4783	15 23	19 48	281 6	10·93	1	6·8, 8·5	·485
h 4776	15 23	41 34	225 6	5·40	2	7, 8·5	·457
h 4788	15 29	44 37	1 5	2·20	2	5, 8	·496
Cord. Z.C. 15^{h}·2046	15 31	31 11	44 7	2·05	2	8, 8·5	·575
Anon.	15 36	14 30	270 5	5·40	2	7·5, 8	·575
Howe 37 ...	15 38	41 30	350 6	3·80	2	6·5, 8·5	·594
β 35	15 38	15 41	100 6	2·60	2	7, 9	·594
ξ Lupi	15 50	33 40	48 6	10·80	1	5·5, 6	·485
ξ Scorpii (AB–C)	15 59	11 6	63 2	7·10	2	4·5, 7·5	·600
β 120 (C–D) ...	16 6	19 12	48 7	2·05	2	7, 8	·594
h 4836	16 11	34 35	298 7	4·25	2	8, 8·5	·600
h 4848	16 17	32 58	154 5	6·09	1	7, 7·5	·594
h 4850	16 18	29 28	350 6	6·25	1	6, 6·5	·659
ρ Ophiuchi ...	16 20	23 13	353 4	3·35	2	5·5, 6	·659
α Scorpii... ...	16 23	26 13	274 7	3·30	2	1, 7·5	·662
P. XVI., 236 ...	16 51	19 23	230 5	4·85	2	6·8, 8	·643
Howe 45... ...	17 0	35 45	23 4	5·15	2	8, 8·5	·643
36 Ophiuchi ...	17 9	26 27	188 8	4·15	2	5·3, 5·5	·594
38 Ophiuchi ...	17 11	26 31	337 5	5·97	2	6·5, 9	·594
β 416	17 12	34 53	287 5	2·25	5	6, 8	·659
O.S. (Ophiuchi) ...	17 12	16 58	290 3	16·9	1	8, 9·3	·643
β 126	17 14	17 39	262 5	2·06	2	6·5, 7·5	·668
Howe 47... ...	17 23	33 38	324 5	4·60	2	7, 9·5	·659
Lac. 7465 ...	17 43	30 31	188 8	10·79	1	7, 8	·600
h 5003	17 53	30 15	104 5	5·37	2	5·3, 7	·600
τ Ophiuchi ...	17 57	8 11	258 7	2·02	2	5·5, 6	·600
h 5014	17 59	43 25	241 6	1·62	3	6, 6	·643
Howe 50. ...	17 59	36 35	3 8	3·22	2	7·8, 8·5	·717
		N					
70 Ophiuchi ...	18 0	2 32	194 4	1·75	6	4, 6	·693
h 5023	18 4	40 27	277 5	8·61	1	8, 8·3	·659
β 245	18 4	30 45	353 4	4·20	2	6, 8	1903·643

Star's Name.	R.A. h m	S. Dec. ° ′	P.A. °	Dist. ″	No. of Nights.	Mags.	Date.
β 132	18 5	19 52	218 6	elongated	2	7, 7·3	1903·643
β 759 (A–B)	18 5	39 22	120 7	1·70	3	8·5, 9	·717
(AB–C)			147 8	15·2	1	9, 9·3	·717
β 639 (AB–C) ...	18 13	18 40	52 0	17·4	1	7, 7·5	·668
Stone 10,006 ...	18 16	42 50	137 9	3·50	2	8·5, 8·8	·668
Jacob 10	18 19	20 36	288 0	1·85	3	5, 8·5	·668
Cor. Z.C. 18^h, 1122	18 19	27 28	358 6	5·52	2	8, 8	·643
β 133	18 22	26 42	260 3	1·70	2	7·5, 7·5	·643
Hh. 567	18 23	25 6	102 0	3·05	2	7·5, 7·8	·643
κ Cor. Australis ...	18 26	38 48	358 8	21·30	1	6, 7	·643
O.S. (Lac. 7763)...	18 28	34 54	137 1	1·75	3	7·8, 8·3	·698
λ Cor. Australis ...	18 37	38 25	214 3	29·6	1	5·5, 9·3	·717
Σ 2373	18 40	10 36	338 5	3·65	2	7, 8	·717
Lac. 7947 ...	18 54	37 12	282 5	12·30	1	7·5, 7·5	·698
Washburn 33 ...	18 56	28 47	58 1	2·70	2	8, 8·8	·668
γ Cor. Australis...	19 0	37 12	134 0	1·90	6	5, 5	·676
South 710 ...	19 0	16 25	0 2	6·28	1	5·8, 8·9	·659
h 5094	19 5	34 0	205 2	15·6	1	7, 7	·643
Cordoba 55 ...	19 8	27 29	329 5	2·25	3	8, 8·3	·698
O. Arg. S. 19,295	19 8	16 11	160 8	5·32	2	8·5, 8·5	·698
h 1381?	19 12	16 7	15 6	15·5	1	6, 7·5	·698
h 596	19 12	16 9	14 1	6·09	2	7·3, 7·8	·698
h 5113	19 19	29 30	164 6	16·5	1	6, 9·3	·698
β 142	19 22	12 21	337 6	1·60	3	8, 8	·698
H. 119	19 24	27 11	140 1	7·47	1	6, 8·8	·668
LL. 37,207 ...	19 33	10 22	323 2	3·65	2	7·3, 9	·728
O.S.	19 42	22 4	5 2	1·65	2	7·8, 8·3	·704
P. XIX., 365 ...	19 57	0 28	294 4	2·15	2	8, 8·5	·734
Cord. Z.C. 20^h, 20	20 3	39 1	261 5	3·40	2	9, 9·3	·704
h 5178	20 7	34 25	9 4	2·85	2	7, 8·5	·704
Dunlop 230 ...	20 11	40 30	116 3	9·65	1	7·3, 7·5	·668
β 762	20 11	32 55	303 9	2·30	2	8, 8·3	·704
Cord. Z.C. 20^h, 417	20 14	27 30	52 2	2·45	2	9, 9·5	·728
A.Oe$_2$ 20,449–50	20 16	18 45	108 6	2·40	2	8, 8·5	·704
Lac. 8390 ...	20 19	40 20	320 5	30·8	1	8, 8·5	·734
π Capricorni ...	20 21	18 36	145 9	3·30	2	5, 9	·717
Howe O.A. 20,494	20 21	26 57	52 4	2·90	2	8·5, 9	·734
ρ Capricorni ...	20 23	18 13	169 2	2·75	2	5, 7·5	·717
Jacob 11	20 27	40 54	223 8	4·30	2	7·5, 8·5	1903·717

Star's Name.	R.A. h m	S. Dec. ° ′	P.A. ° ′	Dist. ″	No. of Nights.	Mags.	Date.
h 1537	20 31	15 40	20 8	3·30	2	8·8, 9·5	1903·720
h 5226	20 43	27 46	66 6	19·1	1	7·5, 8·5	·720
C.G.C. 29,052 ...	21 4	23 37	303 2	8·27	1	8, 9	·717
h 5252	21 7	15 25	319 7	3·53	2	8, 8·5	·704
β 767	21 21	42 59	140 6	2·30	2	5·8, 9	·720
LL. 41,705 ...	21 22	13 52	133 3	2·85	2	8, 9	·734
C.G.C. 29,568 ...	21 35	18 53	66 1	5·03	2	8, 9·4	·717
η Piscis Australis	21 55	28 56	116 6	1·85	3	6, 6·5	·717
29 Aquarii ...	21 57	17 27	242 6	3·90	2	7, 8	·717
β 170	22 3	18 58	58 8	1·65	3	8·5, 8·5	·720
h 5319	22 6	38 48	122 7	2·00	2	8, 8	·720
South 808 ...	22 19	20 52	49 9	7·09	2	7, 8	·734
Σ 2900 (AB–C)	22 19	N 20 21	325 2	67·44	2	6, 9·3	1902·956
ζ Aquarii ...	22 24	0 32	319 7	3·29	2	4·5, 4·6	1903·720
h 5356	22 34	28 52	63 2	3·10	2	7·8, 8·5	·737
Σ 2928	22 34	13 8	313 3	4·18	2	8·8, 8·8	·720
Σ 2944 (A–B) ...	22 43	4 45	258 8	3·16	2	7, 8·3	1902·953
γ Piscis Australis	22 47	33 24	267 6	3·65	2	4·5, 8·5	1903·720
Σ 3008	23 19	9 2	237 4	3·89	2	7·5, 8	·720
h 5417	23 39	26 48	320 9	8·95	2	6, 9·5	·734
ι^2 Aquarii ...	23 41	19 14	138 2	5·90	2	5·5, 7	·720
Σ 3041 (A–C) ...	23 43	N 16 31	351 8	66·11	2	7·3, 8	1902·964
„ (A–B) ...			178 1	3·32	2	7·3, 8	·964
Dunlop 253 ...	23 49	27 36	269 6	6·96	2	6·8, 7·5	1903·734
Σ 3050	23 54	N 30 10	214 6	2·50	2	6, 6	1902·983

Shanghai: 1903 *September.*

Results of Double Star Measures with the 8-inch Equatorial at Windsor, New South Wales, in 1902.

By John Tebbutt.

Ref. No.	Star.	Observed Mags.	Approx. Place of Star. 1902. R.A. h m	Dec. S. ° ′	Fraction of Year.	Position-angle. c	Distance. ″	No. of Obs.	Mag. Power.	Eyes.	Hour-angles. h m	h m	Weight 1 to 5.
1	β Phœnicis	...	1 1·7	47 15	·090	20·1	1·28	10	300	P	2 54 W	3 19 W	4
2	,,	...	,,	,,	·093	19·4	2·16	10–6	300	P	2 49 W	3 10 W	4
3	,,	...	,,	,,	·101	20·6	...	10	230	P	3 4 W	3 32 W	2
4	,,	...	,,	,,	·101	18·6	...	10	300				3
5	p Eridani	...	1 36·1	56 42	·047	222·3	7·37	10–3	300	R	1 39 W	2 9 W	3
6	,,	...	,,	,,	·079	222·4	7·95	10–8	300	R	2 13 W	2 34 W	3
7	,,	...	,,	,,	·082	222·4	7·68	10	300	R	2 5 W	2 29 W	3
8	,,	...	,,	,,	·085	222·6	7·68	10	300	R	2 5 W	2 35 W	4
9	θ Eridani	4½, 5	2 54·5	40 42	·104	84·6	8·26	10–7	300	P	1 11 W	1 43 W	4
10	,,	...	,,	,,	·107	84·4	8·27	10–8	300	P	1 9 W	1 45 W	4
11	,,	...	,,	,,	·107	85·0	...	10	535				3
12	,,	...	,,	,,	·194	87·0	...	10	300	R	3 15 W	4 3 W	4
13	,,	...	,,	,,	·194	86·4	8·53	10	535 / 300	R	3 15 W	4 3 W	4
14	,,	4, 5	,,	,,	·203	87·3	8·38	10	300	R	3 12 W	3 41 W	4
15	12 Eridani	5, 9	3 7·9	29 23	·194	338·4	...	8	300	P	4 1 W	4 39 W	2
16	f Eridani	5½, 5½	3 45·0	37 55	·203	207·2	7·43	10	300	P	3 16 W	3 44 W	5
17	h 3752	6, 7½	5 17·7	24 52	·200	102·4	3·62	10	300	R	2 0 W		5

Ref. No.	Star.	Observed Mags.	Approx. Place of Star. 1902. R.A. h m	Dec. S. ° ′	Fraction of Year.	Position-angle. °	Distance. ″	No. of Obs.	Mag. Power.	Eyes.	Hour-angles. h m	h m	Weight 1 to 5.
18	Lacaille 2145	$6\frac{1}{2}$, 7	6 2·2	48 27	·131	41·8	...	10	300	R	1 1 E	0 33 E	2
19	,,	7, $7\frac{1}{2}$	,,	,,	·298	45·3	2·13	10	300	R	2 56 W	3 31 W	4
20	,,	...	,,	,,	·301	43·1	...	10	300	P			4
21	,,	...	,,	,,	·301	45·6	...	10	300	R	3 33 W	4 18 W	4
22	,,	...	,,	,,	·301	...	1·91	8	300	P			4
23	,,	...	,,	,,	·315	41·7	1·87	10–8	300	P	3 29 W	3 53 W	4
24	,,	...	,,	,,	·320	45·6	...	10	300	R	3 25 W	3 55 W	3
25	*h* 3891	6, $8\frac{1}{2}$	6 41·8	30 51	·146	224·0	...	10	300	R	1 37 E		3
26	γ Piscis Vol.	5, 7	7 9·6	70 20	·110	300·1	13·59	10–6	300	R	2 42 E	2 17 E	4
27	,,	5, $6\frac{1}{2}$	,,	,,	·112	300·8	13·63	10–8	300	R	2 50 E	2 26 E	3
28	*h* 4087	$7\frac{1}{2}$, $7\frac{3}{4}$	8 18·7	40 41	·140	295·5	...	10	300	R	2 47 E	2 21 E	3
29	δ Argûs	4, 8	8 42·0	54 21	·121	168·9	...	10	300	P	4 11 E	3 40 E	3
30	H Velorum	...	8 53·4	52 21	·131	343·0	...	10	300	P	2 17 E	1 52 E	2
31	,,	5, 8	,,	,,	·137	344·1	2·97	10–8	300	P	3 14 E	2 30 E	2
32	*h* 4220	5, $5\frac{1}{2}$	9 30·2	48 34	·137	207·7	2·70	10–6	300	P	2 44 E	2 19 E	2
33	,,	6, $6\frac{1}{2}$	,,	,,	·145	208·5	2·34	10–8	300	P	3 26 E	3 3 E	4
34	,,	$5\frac{1}{2}$, 6	,,	,,	·151	208·4	1·93	10–6	300	P	4 19 E	4 1 E	2
35	,,	6, $6\frac{1}{2}$	,,	,,	·153	208·6	2·27	10–7	300	P	4 22 E	3 58 E	3
36	ν Argûs	3, $7\frac{1}{2}$	9 44·7	64 37	·153	130·2	...	10	230	R	3 18 E	2 43 E	3
37	,,	,,	,,	,,	·153	...	5·01	7	300	R			3

Ref. No.	Star.	Observed Mags.	Approx. Place of Star. 1902. R.A. h m	Dec. S. ° ′	Fraction of Year.	Position-angle. °	Distance. ″	No. of Obs.	Mag. Power.	Eyes.	Hour-angles. h m	h m	Weight 1 to 5.
38	ν Argûs	4, 7	9 44·7	64 37	·162	127·1	5·41	10–7	300	R	4 28 E	4 5 E	3
39	„	4, 7	„	„	·178	126·8	5·32	10–8	300	R	4 13 E	3 51 E	3
40	h 4252	8, 8¼	9 45·4	64 40	·153	124·3	12·49	10–7	140	P	2 43 E	2 12 E	3
41	Lacaille 4102	7, 8¼	9 53·1	68 43	·153	210·1	8·94	10–7	140	P	1 52 E	1 27 E	4
42	h 4310	8, 8¼	10 10·3	83 36	·162	272·2	4·16	10–6	230	R	4 7 E	3 36 E	4
43	h 4329	5, 8	10 27·6	53 13	·137	83·8	32·16	10–7	140	R	2 50 E	2 15 E	3
44	„	5, 8	„	„	·178	84·0	32·27	10–8	140	R	4 10 E	3 35 E	4
45	μ Argûs	4½, 8	10 42·5	48 54	·178	69·3	2·63	10–6	300	R	3 32 E	3 4 E	3
46	„	...	„	„	·189	67·9	...	10	300	R	3 37 E	3 12 E	2
47	„	4½, 8	„	„	·192	65·0	2·65	10–8	300	R	4 39 E	3 55 E	3
48	„	4½, 8	„	„	·192	65·9	...	10	300	R			
49	h 4373	9, 9	10 44·5	40 55	·153	343·5	8·27	8–1	140	P	1 50 E	1 31 E	3
50	„	8½, 9	„	„	·162	345·0	9·88	8–3	140	P	3 47 E	...	3
51	β Hydræ	5, 5½	11 48·0	33 22	·178	351·7	1·80	10	300	P	3 5 E	2 32 E	4
52	„	...	„	„	192	351·9	2·00	10–7	300	P	4 3 E	3 26 E	4
53	α Crucis	...	12 21·2	62 33	·370	117·3	4·90	10	535	R	4 14 E	3 46 E	4
54	„	...	„	„	·372	118·4	4·87	10	535	R	1 17 E	0 35 E	5
55	„	...	„	„	·452	119·1	5·17	10	300	R	3 19 E	2 36 E	4
56	„	...	„	„	·452	118·0	4·98	10	535	R	3 19 E	2 36 E	5
57	„	...	„	„	·460	119·3	4·98	10	300	R	2 39 E	2 16 E	3

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58	γ Centauri	...	12 36·1	48 25	·320	355·9	1·77	10	300	P	2 26 E	1 59 E	4
59	,,	4, 4	,,	,,	·350	354·1	1·95	10	300	P	2 19 E	1 55 E	5
60	,,	4, 4	,,	,,	356	354·4	1·87	10	300	P	2 9 E	1 41 E	5
61	,,	...	,,	,,	·367	354·2	1·93	10	300	P	2 15 E	1 50 E	5
62	,,	...	,,	,,	·386	354·3	1·96	10	535	P	3 29 E	3 8 E	5
63	,,	...	,,	,,	·400	355·1	1·66	10	535	P	3 24 E	3 1 E	5
64	,,	...	,,	,,	·403	355·3	1·84	10	535	P	3 45 E	3 31 E	5
65	,,	...	,,	,,	·405	355·3	1·91	10	300	P	3 11 E	2 45 E	5
66	,,	...	,,	,,	·435	355·1	1·95	10	300	P	2 26 E	2 3 E	3
67	,,	...	,,	,,	·441	354·0	2·09	10	535	P	2 15 E	1 51 E	5
68	,,	...	,,	,,	·449	355·3	1·84	10	300	P	1 43 E	1 17 E	4
69	γ Virginis	...	12 36·7	0 55	·370	147·7	6·04	10–6	535	P	3 47 E	3 26 E	4
70	,,	...	,,	,,	·370	149·3	6·15	10	300	P	2 26 E	2 1 E	5
71	,,	...	,,	,,	·372	150·2	...	10	300	R	0 34 E	0 5 E	5
72	,,	...	,,	,,	·372	...	5·99	10	300	R			4
73	,,	...	,,	,,	·375	148·7	6·17	10	300	P	1 35 E	1 8 E	5
74	β Muscæ	...	12 40·3	67 34	·320	343·0	1·55	10	300	R	1 48 E	1 16 E	4
75	,,	4, 4	,,	,,	·326	341·7	1·95	10	300	R	1 39 E	...	3
76	,,	5, 5	,,	,,	·350	342·4	1·71	10	300	R	1 50 E	1 24 E	4
77	,,	4, 4	,,	,,	·386	345·9	1·78	10	300	R	2 3 E	1 36 E	4

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78	β Muscæ	4, 4	12 40·3	67 34	·397	344·9	1·80	10	300	R	1 52 E	1 24 E	
79	,,	...	,,	,,	·403	342·5	...	10	535	P	3 9 E	2 41 E	5
80	,,	...	,,	,,	·403	...	1·55	10	535	P			4
81	,,	...	,,	,,	·405	342·6	1·66	10	300	R	1 36 E	1 4 E	4
82	θ Muscæ	5, 7½	13 1·8	64 47	·370	187·8	5·48	10–6	300	P	2 6 E	...	4
83	,,	5, 7½	,,	,,	·372	187·2	5·86	10–7	300	P	2 35 E	2 8 E	4
84	k Centauri	5, 6	13 46·2	32 30	·361	109·3	8·35	10	300	P	2 29 E	2 0 E	3
85	,,	5½, 7	,,	,,	·386	110·0	8·49	10	300	P	2 23 E	1 35 E	4
86	y Centauri	6, 6	13 47·8	35 11	·403	90·5	1·60	10	300	R	2 35 E	2 3 E	4
87	Lacaille 5750	7½, 8	13 50·8	55 33	·350	26·9	14·96	10–6	140	P	2 13 E	1 46 E	3
88	Lacaille 5893	5, 7	14 15·6	58 1	·403	162·1	9·79	10	300	P	2 10 E	1 35 E	5
89	α Centauri	...	14 32·9	60 26	·044	212·0	...	10	140	R	3 14 W	3 33 W	2
90	,,	...	,,	,,	·192	211·4	21·65	10	300	P	4 39 W	5 28 W	4
91	,,	...	,,	,,	·192	211·3	21·96	10	535	P			
92	,,	...	,,	,,	·194	211·0	...	10	300	P			4
93	,,	...	,,	,,	·194	211·3	22·24	10–2	535	P	3 51 W	5 30 W	4
94	,,	...	,,	,,	·194	...	22·14	10	535	P			4
95	,,	...	,,	,,	·194	211·0	...	10	535	P			3
96	,,	...	,,	,,	·197	211·6	22·03	10	300	R	3 21 W	4 26 W	4
97	,,	...	,,	,,	·197	210·9	21·83	10	535	P			5

Ref. No.	Star.	Observed Mags.	Approx. Place of Star. 1902. R.A. h m	Dec. S. ° ′	Fraction of Year.	Position-angle. °	Distance. ″	No. of Obs.	Mag. Power.	Eyes.	Hour-angles. h m	h m	Weight 1 to 5.
98	α Centauri	...	14 32·9	60 26	·200	211·2	21·56	10	300	R	4 14 W	5 0 W	5
99	,,	...	,,	,,	·200	211·8	...	10	535	P	4 14 W	5 0 W	5
100	,,	...	,,	,,	·200	...	21·96	10	535	P			4
101	,,	...	,,	,,	·205	211·6	21·58	10	300	R	3 47 W	4 11 W	5
102	,,	...	,,	,,	·205	210·9	22·15	10	535	P	4 11 W	4 30 W	5
103	,,	...	,,	,,	·205	...	21·93	10	170	P	4 30 W	4 56 W	4
104	,,	...	,,	,,	·205	...	21·77	10	170	P	4 56 W	5 9 W	5
105	,,	...	,,	,,	·205	...	21·52	10	170	P	5 11 W	...	4
106	,,	...	,,	,,	·227	...	21·66	10	170	P	4 22 W	4 34 W	3
107	,,	...	,,	,,	·227	...	21·59	10	300	P	4 38 W	4 51 W	4
108	,,	...	,,	,,	·227	211·1	22·24	10	535	P	5 8 W	5 29 W	4
109	,,	...	,,	,,	·227	211·5	...	10	300	P	5 29 W	5 40 W	3
110	,,	...	,,	,,	·241	210·9	21·90	10	300	P	4 53 W	5 39 W	4
111	,,	...	,,	,,	·241	211·2	22·14	10	535	P			
112	,,	1, 2	,,	,,	·252	211·0	22·10	10	300	P	4 18 E	3 47 E	3
113	,,	...	,,	,,	·255	211·7	21·85	10–6	300	P	4 13 E	3 36 E	3
114	,,	...	,,	,,	·257	211·2	...	8	300	R	4 40 E	4 24 E	3
115	,,	...	,,	,,	·263	211·2	21·94	10	300	P	4 18 E	3 50 E	3
116	,,	...	,,	,,	·266	211·4	22·03	10	300	P	3 56 E	3 29 E	2
117	,,	...	,,	,,	·268	211·3	22·10	10	300	P	3 48 E	3 22 E	3

Ref. No.	Star.	Observed Mags.	Approx. Place of Star. 1902. R.A. h m	Dec. S. ° ′	Fraction of Year.	Position-angle. °	Distance. ″	No. of Obs.	Mag. Power.	Eyes.	Hour-angles. h m	h m	Weight 1 to 5.
118	α Centauri	...	14 32·9	60 26	·274	212·0	22·06	10	300	P	3 59 E	3 30 E	4
119	,,	...	,,	,,	·282	211·4	22·10	10	300	P	3 54 E	3 27 E	3
120	,,	...	,,	,,	·400	211·6	21·78	10	535	P	4 51 E	4 20 E	4
121	,,	...	,,	,,	·449	211·3	...	10	300	P	4 21 E	3 52 E	4
122	,,	...	,,	,,	·449	...	21·79	10	300	P			3
123	,,	...	,,	,,	·460	211·2	...	10	300	P	4 12 E	3 49 E	3
124	,,	...	,,	,,	·460	...	22·01	6	300	P			2
125	,,	...	,,	,,	·476	211·1	...	10	300	P	3 30 E	2 59 E	4
126	,,	...	,,	,,	·476	211·7	21·88	10	535	P			
127	,,	...	,,	,,	·479	211·0	21·63	10	535	P	3 23 E	2 56 E	4
128	,,	...	,,	,,	·487	211·0	...	10	300	P	3 33 E	3 0 E	3
129	,,	...	,,	,,	·487	...	21·78	10	535	P			
130	,,	...	,,	,,	·674	...	21·68	10	170	R	0 15 W	0 35 W	3
131	,,	...	,,	,,	·676	...	21·57	10	170	R	1 28 W	1 41 W	3
132	,,	...	,,	,,	·685	...	21·88	10	170	P	3 39 E	3 19 E	2
133	,,	...	,,	,,	·685	...	21·47	10	170	R	2 10 W	2 21 W	3
134	,,	...	,,	,,	·690	...	21·31	10	170	R	3 51 W	4 10 W	3
135	,,	...	,,	,,	·701	...	21·24	10	170	R	1 29 W	1 45 W	3
136	,,	...	,,	,,	·704	...	21·49	10	170	R	1 56 W	2 21 W	3
137	,,	...	,,	,,	·717	...	21·52	10	170	R	1 12 W	1 28 W	3

Ref. No.	Star.	Observed Mags	Approx. Place of Star. 1902. R.A. h m	Dec. S. ° ′	Fraction of Year.	Position-angle. °	Distance. ″	No. of Obs.	Mag. Power.	Eyes.	Hour-angles. h m	h m	Weight 1 to 5.
138	α Centauri	...	14 32·9	60 26	·717	...	21·65	8	170	R	...	3 26 W	3
139	,,	...	,,	,,	·720	...	21·40	10	170	R	1 46 W	2 3 W	3
140	,,	...	,,	,,	·720	...	21·45	10	170	R	...	2 49 W	4
141	,,	...	,,	,,	·720	...	21·50	10	170	R	3 0 W	3 12 W	3
142	,,	...	,,	,,	·728	...	21·47	10	170	R	2 17 W	2 31 W	4
143	,,	...	,,	,,	·728	...	21·56	10	170	R	2 38 W	2 52 W	4
144	,,	...	,,	,,	·728	...	21·52	10	170	R	2 54 W	3 8 W	5
145	,,	...	,,	,,	·728	...	21·54	10	170	R	3 8 W	3 24 W	3
146	,,	...	,,	,,	·731	...	21·56	10	170	R	2 22 W	2 35 W	4
147	,,	...	,,	,,	·731	...	21·56	10	170	R	2 35 W	2 49 W	4
148	α Circini	3, 8	14 34·6	64 33	·350	236·8	...	10	300	P	2 14 E	1 46 E	4
149	,,	3, 8	,,	,,	·350	...	16·39	6	140	P			
150	,,	4, 8	,,	,,	·367	237·7	...	10	300	P	3 37 E	3 4 E	4
151	,,	4, 8	,,	,,	·367	...	15·81	6	140	P			
152	*m* Hydræ	5, 6½	14 40·3	25 2	·392	129·0	...	10	300	P	2 39 E	2 5 E	4
153	,,	5, 6½	,,	,,	·392	...	9·14	10	300	P			5
154	,,	...	,,	,,	·405	131·3	9·08	10–2	300	P	2 44 E	2 11 E	4
155	,,	5, 8	,,	,,	·408	130·8	8·63	10	300	P	3 17 E	2 33 E	5
156	59 Hydræ	6½, 6½	14 52·9	27 16	·408	318·8	...	10	300	P	2 32 E	2 9 E	4
157	π Lupi		14 58·5	46 40	·367	86·7	1·66	10	300	R	3 18 E	2 51 E	5

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158	π Lupi	5, 5	14 58·5	46 40	·375	87·4	...	10	300	R	2 30 E	2 9 E	5
159	,,	5, 5	,,	,,	·375	...	1·51	10	300	R			4
160	,,	5, 5	,,	,,	·408	85·0	...	10	300	R	2 4 E	1 33 E	5
161	,,	5, 5	,,	,,	·408	87·2	1·50	10–6	535	R			
162	κ Lupi	$4\frac{1}{2}$, 6	15 5·1	48 22	·392	144·4	27·40	10	300	P	2 15 E	1 38 E	5
163	μ Lupi	5, 5	15 11·7	47 31	·340	156·3	1·75	10	300	P	3 25 E	2 56 E	4
164	,,	5. 5	,,	,,	·386	155·1	1·89	10	300	P	4 8 E	3 41 E	5
165	,,	5, 5	,,	,,	·441	155·6	2·09	10	300	P	2 41 E	2 17 E	5
166	Dunlop 180	5. 7	,,	,,	·340	130·8	...	10	300	P	2 56 E	2 27 E	4
167	,,	5, 7	,,	,,	·340	...	23·18	5	140	P			
168	γ Circini	5. $5\frac{1}{4}$	15 15·6	58 58	·367	80·1	1·64	10	300	R	2 49 E	2 23 E	4
169	,,	5, 5	,,	,,	·375	81·8	...	10	300	R	2 15 E	2 1 E	4
170	,,	5, $5\frac{1}{4}$	,,	,,	·386	78·8	1·60	10	300	R	2 45 E	2 17 E	4
171	,,	5, $5\frac{1}{2}$	,,	,,	·441	79·1	1·89	10	300	P	2 6 E	1 37 E	4
172	ϵ Lupi	5, 8	15 16·0	44 20	·449	276·2	1·39	10	300	R	2 46 E	2 22 E	5
173	ϵ Lupi & Dunlop 182	5, 7	15 16·0	44 20	·449	172·5	...	10	140	P	2 46 E	2 22 E	4
174	d Lupi	5, 7	15 29·0	44 38	·340	358·1	2·47	10	300	P	2 23 E	1 52 E	4
175	,,	$5\frac{1}{2}$, $7\frac{1}{2}$	,,	,,	·356	359·0	2·58	10	300	P	3 52 E	3 26 E	5
176	,,	5, 8	,,	,,	·375	356·3	2·63	10–8	300	P	3 49 E	3 21 E	3
177	Lacaille 6477	$6\frac{1}{2}$. $6\frac{1}{2}$	15 38·9	65 8	·397	153·7	2·52	10	300	P	3 56 E	3 22 E	5

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178	A Scorpii	5, 8	15 47·7	25 2	·449	277·7	3·08	10	300	R	2 16 E	1 51 E	5
179	,,	5, 8	,,	,,	·476	276·5	3·17	10	300	R	2 32 E	1 59 E	4
180	,,	5, 8	,,	,,	·487	275·5	2·97	10	300	R	2 6 E	1 38 E	5
181	η Lupi	5, 8	15 53·6	38 7	·356	20·8	15·12	10–5	300	P	3 31 E	3 6 E	4
182	ν Scorpii	4, 6	16 6·3	19 12	·400	7·5	...	5	535	P	2 52 E	2 6 E	3
183	,,	4, 6	,,	,,	·400	10·9	...	10	300	P			
184	,,	$5\frac{1}{2}$, 7	,,	,,	·427	8·2	...	10	300	P	3 24 E	2 35 E	2
185	,,	$5\frac{1}{2}$, 7	,,	,,	·427	4·9	...	10	300	P			3
186	,,	5, $6\frac{1}{2}$	,,	,,	·452	0·9	...	10	300	P	2 36 E	2 8 E	4
187	Jacob 9	$7\frac{1}{2}$, $7\frac{3}{4}$	16 6·3	19 12	·400	49·6	...	10	300	R	2 52 E	2 6 E	3
188	,,	7, $7\frac{1}{2}$	,,	,,	·427	51·4	...	10	300	R	3 24 E	2 35 E	3
189	,,	$6\frac{1}{2}$, 7	,,	,,	·452	50·2	...	10	300	R	2 36 E	2 8 E	4
190	ρ Ophiuchi	5, $5\frac{1}{4}$	16 19·7	23 13	·394	355·0	3·70	10	300	P	2 56 E	2 28 E	5
191	,,	...	,,	,,	·427	356·3	3·80	10	300	P	2 35 E	2 8 E	4
192	A Ophiuchi	5, 5	17 9·3	26 27	·394	192·4	4·49	10	300	P	3 3 E	2 25 E	5
193	,,	$5\frac{1}{2}$, $5\frac{1}{2}$	,,	,,	·427	191·8	4·76	10	300	P	2 39 E	2 12 E	5
194	,,	6, 6	,,	,,	·452	190·8	4·98	10	300	P	2 52 E	2 26 E	4
195	Lacaille 7194	6, $8\frac{1}{2}$	17 11·6	46 32	·441	83·6	...	10	300	R	3 15 E	2 52 E	3
196	,,	$5\frac{1}{2}$, 9	,,	,,	·449	84·4	2·83	10–7	300	R	2 48 E	2 26 E	5

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197	Lacaille 7194	5½, 8½	17 11·6	46 32	·476	85·0	...	10	300	R	2 56 E	2 29 E	4
198	,,	5½, 8½	,,	,,	·476	...	2·24	7	300	R			3
199	,,	5½, 8½	,,	,,	·485	81·7	2·54	10	300	R	3 42 E	3 8 E	4
200	,,	5, 8½	,,	,,	·487	81·8	2·16	10	300	R	2 26 E	1 55 E	4
201	,,	5, 8½	,,	,,	·493	83·6	2·20	10	300	R	3 7 E	2 22 E	3
202	β 416	6½, 7	17 12·2	34 53	·479	288·7	2·56	10	300	R	2 29 E	1 59 E	4
203	,,	6, 6½	,,	,,	·485	289·7	...	10	300	R	2 22 E	1 55 E	4
204	,,	6, 7	,,	,,	·490	291·0	2·52	10	300	P	3 36 E	3 1 E	3
205	,,	6, 7	,,	,,	·493	291·1	2·56	10–5	300	R	2 7 E	1 40 E	3
206	,,	7, 8	,,	,,	·496	289·5	2·63	10	300	R	3 6 E	2 38 E	5
207	h 4949	6, 6½	17 19·6	45 45	·485	262·2	2·76	10	300	R	3 9 E	2 43 E	5
208	h 5014	6, 6	17 59·7	43 26	·479	242·6	2·07	10	300	R	1 44 E	1 13 E	5
209	γ Coronæ Aust.	5½, 5½	18 59·8	37 12	·394	136·1	1·87	10	300	P	3 48 E	3 21 E	5
210	,,	5, 5	,,	,,	·427	135·6	...	10	300	P	3 47 E	3 12 E	4
211	,,	5, 5	,,	,,	·427	...	2·04	10	300	P			3
212	,,	5½, 5½	,,	,,	·476	136·3	2·22	10	300	P	4 3 E	3 35 E	3
213	,,	5, 5	,,	,,	·479	136·4	2·24	10	300	P	3 25 E	3 0 E	5
214	,,	5½, 5½	,,	,,	·485	135·2	2·20	10	300	P	3 38 E	3 6 E	4
215	,,	5, 5	,,	,,	·487	133·3	2·45	10	300	P	3 27 E	3 3 E	5
216	,,	5, 5	,,	,,	·496	136·3	2·13	10	300	P	4 2 E	3 33 E	5

Remarks.

1, 2 3, 4, 5, 6, 7, 8. 9, 10, 11, 25, 26, 27, 34, 35, 38, 39, 62, 63, 65, 66, 67, 69, 79, 80, 120, 124, 125, 126, 127, 133, measures in twilight. 53, 55, 56, 57. 64, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 123, 130, 131, 132, 135, 136, 137, 138, 139, 140, 142, 143, 144, 145, 146, 147, measures in sunlight. 1, 2, 3, 4, 5, 6, 7, 8, 59, 60, 65, 66, 71, 72, 75, 77, 78, 86, 156, 157, 158, 159, 160, 161, 163, 164, 165, 177, 192, 193, 194, 208, 209, 210, 211, 212, 213, 214, 215, 216, components equal. 16, north component probably the brighter. 17, principal component yellow, companion blue. 18, hazy and ill-defined. 19, preceding and south component the brighter. 20, 21, 22, 23, nearly equal. 26, 27, 36, 37, 38, 39, principal component orange and companion blue. 29, 31, observations very difficult. 36, 37, 38, 39, erroneously called *h* 4252 in Innes' Reference Catalogue. 40, not in the Reference Catalogue. 43, 44, principal component white and companion reddish. 45, principal component yellow, companion pale green. 47, 48, principal component orange, companion greenish. 49, south component the brighter. 51, a neat and beautiful pair. 74, 190, following and south component the brighter. 79, 80, south component certainly slightly the brighter. 82, principal component white, companion blue. 103, 104, 105, 106, 107, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, measures with the Grubb distance filar micrometer. 121, 122, 128, 129, 141, measures partly in sunlight and partly in twilight. 156, components just separated, distance less than 1″. 166, 167, the position-angle is referred to the mean of μ Lupi. 173, Innes' Catalogue makes the companion = 10 mag. 175, a minute companion suspected midway between the components, but a little west of the line joining them. 182, 183, measures difficult, estimated distance = 1″. 184, 185, distance about 1″. 188, distance about 2″. 195, principal component reddish and rather blurred, distance about 3″. 196, 199, 200, companion hazy. 205, 206, a companion about $8\frac{1}{2}$ or 9 mag. south, and following at a distance of 20″ or 30″.

On March 7 I attempted to observe γ *Carinæ* = Innes' No. 6, 11^h, but the definition was not good enough to enable me to distinguish the companion measured here in 1901, nor could I see the companion = 10 mag. recorded by Herschel and Pollock. Brisbane 3574 = Innes' No. 22, 11^h, was woolly and could not be seen double. On May 5 I examined θ *Centauri* = No. 2, 14^h of Innes' Catalogue, but could find no trace of a companion.

The arrangement of the preceding table is similar to that adopted in former communications. All the measures, except where otherwise stated, have been made with the Cooke position and distance filar micrometer.

Observatory, Peninsula, Windsor, N.S. Wales:
1903 *August.*

Additional Note to Paper on a New Method of Determining Time, Latitude, and Azimuth with a Theodolite. By W. Ernest Cooke, M.A.

In my article on a method of determining time, &c. (*Monthly Notices*, lxiii. p. 161), an error in the formula for latitude occurs.

The quantity L should be taken out for each clock star, as well as for those observed especially for latitude. Since the values of Z, L, &c., differ from one another so considerably in the latitude stars it will be better to compute $\Delta\phi$ separately for each pair, rather than take the mean of all the east and west stars respectively, as may be done in the case of clock stars.

Now let L_1 Z_1 be the mean of all the L*s* and Z*s* for clock stars, considered positive throughout, no matter whether east or west; and let L_2 Z_2 be the *sum* of the L*s* and Z*s* for the latitude pair, also considered positive throughout. Then instead of $c = L - L'$, we must put

$$c = L_2 - \frac{L_1}{Z_1} Z_2$$

A misprint on p. 160 may also cause confusion. In the middle section of that page the quantity Z should in each case be written *z* (small); and on p. 159 at the end of § 1 read

$$\tan \tfrac{1}{2} A = \sin \phi \tan t$$

If a number of observations are to be taken in the same place, it may be as well to compute t_o, from an approximate value of $\delta = \delta_o$ (say). Then the t corresponding to the apparent δ at date, from the *N.A.*, $= t_o + D(\delta_o - \delta)$ for the southern, and $= t_o + D(\delta - \delta_o)$ for the northern hemisphere. In this case N declination is + and south −.

Also if t_o has been computed for any assumed latitude φ_o, and if it be desired to correct it for a latitude φ, differing not very greatly from ϕ, we have

$$t = t_o + (\phi - \varphi_o)L$$

Perth Observatory, Western Australia:
1903 *October* 13.

Ephemeris for Physical Observations of the Moon, 1904.

By A. C. D. Crommelin.

Greenwich, Midnight.	Selenographical Colong.	Selenographical Lat. of the Sun.	Geocentric Libration Sel. Long.	Geocentric Libration Lat. of the Earth.	Combined Amount.	Direction.	C.
1904.	°	°	°	°	°	°	°
Jan. 1	77·60	+1·52	-4·79	+6·44	8·02	36·6	356·82
2	89·73	1·52	−3·08	+6·47	7·17	25·5	3·43
3	101·86	1·51	−1·17	+6·06	6·17	10·9	9·86
4	113·98	1·50	+0·79	+5·21	5·27	351·4	15·55
5	126·10	1·49	+2·60	+4·01	4·78	327·0	20·08
6	138·23	1·48	+4·15	+2·56	4·88	301·7	23·17
7	150·37	1·47	+5·34	+0·97	5·43	280·3	24·75
8	162·51	1·46	+6·15	−0·63	6·18	264·2	24·84
9	174·66	1·45	+6·60	−2·17	6·95	251·8	23·57
10	186·82	1·44	+6·72	−3·55	7·60	242·2	21·08
11	198·99	1·43	+6·56	−4·71	8·08	234·3	17·53
12	211·16	1·42	+6·17	−5·61	8·34	227·7	13·14
13	223·34	1·41	+5·58	−6·23	8·36	221·8	8·14
14	235·52	1·40	+4·83	−6·54	8·13	216·4	2·75
15	247·71	1·38	+3·92	−6·55	7·63	210·9	357·30
16	259·89	1·37	+2·89	−6·26	6·90	204·8	352·05
17	272·08	1·36	+1·73	−5·69	5·95	196·9	347·23
18	284·27	1·35	+0·46	−4·88	4·90	185·4	343·05
19	296·46	1·34	−0·90	−3·86	3·96	166·9	339·66
20	308·65	1·33	−2·30	−2·68	3·53	139·4	337·15
21	320·83	1·32	−3·70	−1·38	3·95	110·5	335·59
22	333·01	1·31	−5·04	−0·01	5·04	90·1	335·02
23	345·18	1·30	−6·23	+1·37	6·38	77·6	335·50
24	357·35	1·28	−7·19	+2·72	7·69	69·3	337·04
25	9·51	1·27	−7·83	+3·98	8·78	63·1	339·70
26	21·67	1·26	−8·07	+5·07	9·53	57·9	343·46
27	33·82	1·24	−7·83	+5·92	9·82	52·9	348·29
28	45·96	1·23	−7·07	+6·47	9·59	47·5	354·03
29	58·10	1·21	−5·81	+6·63	8·81	41·2	350·39
30	70·23	1·19	−4·12	+6·35	7·57	33·0	6·91
31	82·35	1·17	−2·12	+5·63	6·01	20·6	13·03
Feb. 1	94·48	1·15	+0·01	+4·50	4·50	359·9	18·21
2	106·60	1·13	+2·08	+3·05	3·69	325·7	22·04
3	118·73	+1·10	+3·93	+1·40	4·17	289·6	24·31

Greenwich Midnight.	Selenographical Colong.	Lat. of the Sun.	Geocentric Libration Sel. Long. of the Earth.	Lat.	Combined Amount.	Direction.	C.
1904.	°	°	°	°	°	°	°
Feb. 4	130·86	+1·08	+5·44	−0·32	5·45	266·6	24·97
5	143·01	1·05	+6·52	−1·96	6·81	253·3	24·10
6	155·15	1·03	+7·18	−3·45	7·97	244·3	21·87
7	167·31	1·01	+7·42	−4·69	8·78	237·7	18·51
8	179·47	0·98	+7·29	−5·66	9·23	232·2	14·24
9	191·64	0·96	+6·85	−6·32	9·32	227·3	9·31
10	203·82	0·94	+6·14	−6·66	9·06	222·7	4·00
11	216·00	0·92	+5·22	−6·70	8·49	217·9	358·56
12	228·19	0·90	+4·14	−6·44	7·65	212·7	353·27
13	240·38	0·88	+2·93	−5·89	6·58	206·4	348·36
14	252·57	0·85	+1·64	−5·10	5·36	197·8	344·02
15	264·77	0·83	+0·29	−4·09	4·10	184·1	340·42
16	276·97	0·81	−1·09	−2·90	3·10	159·4	337·68
17	289·17	0·79	−2·47	−1·59	2·94	122·8	335·88
18	301·37	0·77	−3·80	−0·20	3·81	93·0	335·07
19	313·56	0·75	−5·04	+1·21	5·18	76·5	335·29
20	325·75	0·73	−6·13	+2·59	6·66	67·1	336·58
21	337·93	0·70	−7·01	+3·86	8·00	61·2	338·91
22	350·12	0·68	−7·62	+4·98	9·11	56·8	342·30
23	2·29	0·66	−7·88	+5·88	9·83	53·3	346·70
24	14·46	0·63	−7·74	+6·49	10·10	50·0	351·99
25	26·63	0·61	−7·16	+6·76	9·84	46·6	357·95
26	38·78	0·58	−6·14	+6·63	9·04	42·8	4·24
27	50·93	0·55	−4·71	+6·07	7·68	37·8	10·40
28	63·07	0·53	−2·95	+5·10	5·89	30·0	15·95
29	75·21	0·49	−0·98	+3·75	3·83	11·7	20·41
Mar. 1	87·35	0·46	+1·03	+2·14	2·37	334·3	23·45
2	99·49	0·43	+2·94	+0·37	2·96	277·2	24·87
3	111·63	0·40	+4·60	−1·39	4·80	253·2	24·64
4	123·77	0·37	+5·90	−3·02	6·63	242·9	22·89
5	135·92	0·34	+6·78	−4·42	8·09	236·9	19·82
6	148·08	0·31	+7·23	−5·52	9·10	232·6	15·70
7	160·25	0·28	+7·26	−6·29	9·61	229·1	10·81
8	172·42	0·25	+6·90	−6·72	9·62	225·8	5·47
9	184·61	0·23	+6·21	−6·82	9·22	222·3	359·96
10	196·79	0·20	+5·25	−6·61	8·45	218·5	354·58
11	208·99	0·17	+4·10	−6·12	7·37	213·8	349·54
12	221·18	+0·15	+2·81	−5·36	6·05	207·7	345·05

Greenwich Midnight.	Selenographical Colong. of the Sun.	Selenographical Lat. of the Sun.	Geocentric Libration Sel. Long. of the Earth.	Geocentric Libration Lat. of the Earth.	Combined Amount.	Direction.	C.
1904.	°	°	°	°	°	°	°
Mar. 13	233·39	+0·12	+1·40	−4·38	4·60	197·7	341·26
14	245·59	0·10	+0·05	−3·22	3·22	180·9	338·29
15	257·81	0·07	−1·31	−1·91	2·32	145·5	336·25
16	270·02	0·05	−2·61	−0·51	2·66	101·1	335·18
17	282·23	0·02	−3·79	+0·92	3·90	76·4	335·14
18	294·45	0·00	−4·84	+2·33	5·37	64·3	336·17
19	306·65	−0·02	−5·70	+3·64	6·77	57·4	338·28
20	318·86	0·05	−6·35	+4·81	7·96	52·9	341·45
21	331·06	0·08	−6·75	+5·75	8·66	49·6	345·61
22	343·26	0·10	−6·88	+6·42	9·41	47·0	350·63
23	355·46	0·13	−6·71	+6·77	9·53	44·7	356·32
24	7·64	0·16	−6·21	+6·74	9·17	42·7	2·38
25	19·82	0·18	−5·39	+6·32	8·31	40·5	8·43
26	32·00	0·21	−4·26	+5·50	6·96	37·8	14·04
27	44·16	0·24	−2·88	+4·32	5·19	33·7	18·80
28	56·32	0·28	−1·30	+2·83	3·12	24·7	22·34
29	68·48	0·31	+0·38	+1·14	1·20	341·6	24·44
30	80·64	0·34	+2·04	−0·62	2·13	253·1	24·94
31	92·79	0·37	+3·57	−2·33	4·26	236·9	23·86
Apr. 1	104·95	0·40	+4·85	−3·86	6·20	231·5	21·31
2	117·11	0·43	+5·81	−5·12	7·75	228·6	17·51
3	129·28	0·46	+6·37	−6·04	8·78	226·5	12·76
4	141·45	0·49	+6·53	−6·60	9·29	224·7	7·40
5	153·63	0·51	+6·27	−6·81	9·25	222·6	1·78
6	165·81	0·54	+5·66	−6·68	8·76	220·3	356·21
7	178·01	0·56	+4·74	−6·25	7·85	217·2	350·97
8	190·20	0·59	+3·59	−5·56	6·61	212·8	346·26
9	202·41	0·61	+2·28	−4·63	5·16	206·2	342·25
10	214·62	0·63	+0·90	−3·51	3·62	194·4	339·04
11	226·83	0·66	−0·49	−2·24	2·29	167·7	336·73
12	239·05	0·68	−1·80	−0·87	2·00	115·8	335·37
13	251·28	0·70	−2·99	+0·55	3·04	79·6	335·05
14	263·50	0·72	−3·99	+1·97	4·45	63·7	335·79
15	275·74	0·74	−4·78	+3·31	5·81	55·3	337·63
16	287·97	0·76	−5·32	+4·52	6·99	49·6	340·57
17	300·20	0·78	−5·63	+5·51	7·88	45·6	344·54
18	312·42	0·80	−5·69	+6·24	8·45	42·4	349·43
19	324·64	−0·82	−5·51	+6·64	8·63	39·7	355·03

Greenwich Midnight.	Selenographical Colong. of the Sun.	Selenographical Lat. of the Sun.	Geocentric Libration Sel. Long. of the Earth.	Geocentric Libration Lat. of the Earth.	Combined Amount.	Direction.	C.
1904.	°	°	°	°	°	°	°
Apr. 20	336·86	−0·85	−5·11	+6·69	8·42	37·4	1·03
21	349·07	0·87	−4·51	+6·35	7·79	35·4	7·05
22	1·28	0·89	−3·73	+5·63	6·75	33·5	12·70
23	13·48	0·92	−2·80	+4·57	5·36	31·5	17·58
24	25·67	0·94	−1·72	+3·21	3·64	28·2	21·40
25	37·85	0·96	−0·54	+1·64	1·73	18·2	23·90
26	50·03	0·99	+0·70	−0·04	0·70	266·7	24·94
27	62·21	1·01	+1·94	−1·72	2·59	228·5	24·47
28	74·38	1·04	+3·11	−3·28	4·52	223·5	22·52
29	86·55	1·06	+4·13	−4·61	6·19	221·9	19·22
30	98·72	1·08	+4·92	−5·64	7·49	221·1	14·81
May 1	110·90	1·10	+5·41	−6·33	8·33	220·5	9·60
2	123·08	1·12	+5·54	−6·65	8·66	219·8	3·95
3	135·27	1·14	+5·30	−6·62	8·48	218·7	358·21
4	147·46	1·16	+4·71	−6·27	7·84	216·9	352·72
5	159·65	1·18	+3·82	−5·64	6·81	214·1	347·73
6	171·86	1·19	+2·68	−4·77	5·47	209·3	343·43
7	184·06	1·21	+1·37	−3·70	3·94	200·3	339·94
8	196·28	1·22	−0·01	−2·48	2·48	179·8	337·34
9	208·50	1·24	−1·38	−1·16	1·80	130·1	335·69
10	220·73	1·25	−2·65	+0·23	2·66	85·0	335·03
11	232·97	1·26	−3·73	+1·63	4·07	66·4	335·44
12	245·20	1·27	−4·57	+2·97	5·45	57·0	336·93
13	257·44	1·28	−5·12	+4·19	6·62	50·7	339·55
14	269·69	1·30	−5·35	+5·23	7·48	45·2	343·25
15	281·93	1·31	−5·26	+6·01	7·99	41·2	347·97
16	294·18	1·32	−4·89	+6·47	8·11	37·1	353·50
17	306·41	1·33	−4·29	+6·57	7·84	33·1	359·54
18	318·65	1·34	−3·52	+6·28	7·20	29·3	5·69
19	330·88	1·36	−2·65	+5·62	6·21	25·2	11·52
20	343·10	1·37	−1·72	+4·61	4·92	20·5	16·62
21	355·32	1·38	−0·78	+3·31	3·40	13·3	20·66
22	7·53	1·40	+0·16	+1·82	1·83	355·0	23·44
23	19·74	1·41	+1·07	+0·21	1·09	281·1	24·81
24	31·94	1·43	+1·95	−1·41	2·41	234·1	24·75
25	44·14	1·44	+2·79	−2·93	4·05	223·6	23·27
26	56·33	1·45	+3·54	−4·27	5·55	219·7	20·46
27	68·51	−1·46	+4·17	−5·34	6·78	218·0	16·48

Greenwich Midnight.	Selenographical Colong. of the Sun.	Selenographical Lat. of the Sun.	Geocentric Libration Sel. Long. of the Earth.	Geocentric Libration Lat.	Combined Amount.	Direction.	C.
1904.	°	°	°	°	°	°	°
May 28	80·70	−1·47	+4·62	−6·09	7·64	217·2	11·57
29	92·88	1·48	+4·84	−6·49	8·09	216·7	6·06
30	105·07	1·49	+4·78	−6·54	8·10	216·2	0·29
31	117·26	1·49	+4·42	−6·26	7·66	215·2	354·63
June 1	129·46	1·50	+3·74	−5·68	6·80	213·4	349·37
2	141·65	1·50	+2·81	−4·85	5·54	209·0	344·78
3	153·86	1·50	+1·64	−3·82	4·16	203·2	340·97
4	166·07	1·51	+0·32	−2·63	2·65	186·9	338·08
5	178·29	1·51	−1·07	−1·33	1·71	141·2	336·11
6	190·51	1·51	−2·44	+0·03	2·44	89·3	335·14
7	202·74	1·51	−3·68	+1·39	3·93	69·3	335·19
8	214·97	1·51	−4·71	+2·72	5·44	60·0	336·31
9	227·21	1·51	−5·45	+3·95	6·73	54·1	338·51
10	239·46	1·51	−5·83	+5·01	7·69	49·3	341·82
11	251·70	1·51	−5·82	+5·83	8·23	44·9	346·29
12	263·95	1·51	−5·41	+6·36	8·35	40·4	351·52
13	276·20	1·51	−4·66	+6·52	8·02	35·6	357·52
14	288·45	1·51	−3·64	+6·30	7·27	30·0	3·83
15	300·70	1·51	−2·44	+5·67	6·17	23·3	9·94
16	312·95	1·51	−1·18	+4·68	4·83	14·2	15·41
17	325·19	1·51	+0·06	+3·39	3·39	359·0	19·82
18	337·42	1·51	+1·18	+1·90	2·25	327·8	22·94
19	349·65	1·51	+2·18	+0·29	2·20	277·6	24·64
20	1·87	1·52	+3·03	−1·32	3·30	246·5	24·89
21	14·09	1·51	+3·73	−2·83	4·68	232·8	23·72
22	26·30	1·51	+4·28	−4·16	5·97	225·8	21·26
23	38·50	1·51	+4·68	−5·24	7·03	221·8	17·63
24	50·70	1·51	+4·93	−6·01	7·78	219·4	13·03
25	62·90	1·51	+5·00	−6·45	8·16	217·8	7·76
26	75·09	1·50	+4·87	−6·54	8·16	216·7	2·10
27	87·28	1·49	+4·51	−6·31	7·76	215·6	356·41
28	99·48	1·49	+3·91	−5·77	6·97	214·1	351·01
29	111·67	1·48	+3·07	−4·96	5·84	211·8	346·17
30	123·87	1·47	+2·01	−3·95	4·43	207·0	342·08
July 1	136·07	1·46	+0·77	−2·77	2·87	195·5	338·88
2	148·28	1·45	−0·60	−1·48	1·60	157·9	336·62
3	160·49	1·43	−2·01	−0·12	2·01	93·4	335·33
4	172·70	−1·42	−3·39	+1·24	3·61	69·9	335·06

Greenwich Midnight.	Selenographical Colong. of the Sun.	Lat. of the Sun.	Geocentric Libration: Sel. Long. of the Earth.	Lat. of the Earth.	Combined Amount.	Direction.	C.
1904.	°	°	°	°	°	°	°
July 5	184·93	−1·41	−4·64	+2·56	5·30	61·1	335·82
6	197·16	1·40	−5·66	+3·79	6·81	56·2	337·62
7	209·39	1·39	−6·37	+4·87	8·02	52·6	340 50
8	221·63	1·37	−6·69	+5·74	8·81	49·4	344·43
9	233·87	1·36	−6·58	+6·33	9·13	46·1	349·36
10	246·12	1·35	−6·01	+6·58	8·91	42·4	355·10
11	258·37	1·34	−5·02	+6·45	8·18	37·9	1 37
12	270·63	1·33	−3·70	+5·91	6·97	32·0	7·69
13	282·88	1·31	−2·15	+4·96	5·41	23·4	13·57
14	295·14	1·30	−0·51	+3·68	3·71	7·9	18·51
15	307·38	1·29	+1·09	+2·15	2·41	333·1	22·16
16	319·63	1·28	+2·54	+0·49	2·59	280·9	24·32
17	331·86	1·27	+3·76	−1·19	3·94	252·4	24·95
18	344·09	1·26	+4·74	−2·76	5·48	239·8	24·09
19	356·31	1·25	+5·44	−4·13	6·83	232·8	21·88
20	8·53	1·23	+5·89	−5·25	7·89	228·3	18·50
21	20·74	1·22	+6·09	−6·05	8·58	225·2	14·15
22	32·95	1·20	+6·06	−6·52	8·90	222·9	9·04
23	45·15	1·19	+5·81	−6·65	8·83	221·1	3·53
24	57·34	1·17	+5·34	−6·45	8·37	219·6	357·89
25	69·54	1·15	+4·68	−5·94	7·56	218·2	352·43
26	81·73	1·13	+3·81	−5·16	6·41	216·4	347·47
27	93·92	1·11	+2·76	−4·16	4·99	213·6	343·13
28	106·11	1·09	+1·55	−2·98	3·36	207·5	339·69
29	118·31	1·06	+0·22	−1·68	1·69	187·5	337·16
30	130·51	1·04	−1·20	−0·32	1·24	104·9	335·60
31	142·71	1·02	−2·62	+1·06	2·83	68·0	335·04
Aug. 1	154·91	1·00	−4·00	+2·41	4·67	58·9	335·50
2	167·12	0·97	−5·24	+3·66	6·39	55·1	336·98
3	179·34	0·95	−6·26	+4·76	7·86	52·8	339·47
4	191·55	0·93	−6·99	+5·68	9·01	50·9	342·98
5	203·78	0·91	−7·33	+6·34	9·70	49·1	347·47
6	216·01	0·88	−7·25	+6·68	9·87	47·3	352·79
7	228·25	0·86	−6·69	+6·67	9·45	45·1	358·78
8	240·49	0·84	−5·67	+6·25	8·44	42·2	5·05
9	252·73	0·82	−4·26	+5·43	6·90	38·1	11·15
10	264·98	0·80	−2·55	+4·22	4·93	31·1	16·58
11	277·23	−0·78	−0·67	+2·71	2·79	13·9	20·87

Greenwich Midnight.	Selenographical Colong. of the Sun.	Selenographical Lat. of the Sun.	Geocentric Libration Sel. Long. of the Earth.	Geocentric Libration Lat. of the Earth.	Combined Amount.	Direction.	C.
1904.	°	°	°	°	°	°	°
Aug. 12	289·48	−0·76	+1·22	+1·00	1·58	309·3	23·69
13	301·72	0·74	+2·99	−0·77	3·09	255·6	24·91
14	313·96	0·72	+4·52	−2·46	5·15	241·4	24·51
15	326·20	0·70	+5·74	−3·96	6·97	235·4	22·62
16	338·43	0·68	+6·60	−5·17	8·39	231·9	19·45
17	350·65	0·66	+7·11	−6·06	9·34	229·6	15·22
18	2·86	0·64	+7·26	−6·60	9·81	227·7	10·22
19	15·06	0·61	+7·10	−6·78	9·82	226·3	4·78
20	27·26	0·59	+6·64	−6·62	9·38	225·1	359·18
21	39·46	0·56	+5·94	−6·16	8·56	224·0	353·68
22	51·65	0·53	+5·02	−5·41	7·39	222·9	348·61
23	63·84	0·51	+3·93	−4·43	5·92	221·6	344·16
24	76·02	0·48	+2·69	−3·27	4·23	219·4	340·49
25	88·21	0·45	+1·36	−1·97	2·39	214·6	337·71
26	100·39	0·42	−0·04	−0·60	0·60	176·2	335·91
27	112·58	0·39	−1·46	+0·81	1·67	61·0	335·09
28	124·76	0·36	−2·85	+2·18	3·59	52·6	335·30
29	136·95	0·33	−4·17	+3·46	5·42	50·3	336·51
30	149·14	0·30	−5·35	+4·61	7·06	49·3	338·73
31	161·34	0·28	−6·32	+5·57	8·43	48·6	341·92
Sept. 1	173·54	0·25	−7·03	+6·28	9·43	48·2	346·04
2	185·74	0·22	−7·41	+6·71	10·00	47·8	351·00
3	197·95	0·20	−7·41	+6·80	10·05	47·5	356·62
4	210·17	0·17	−6·98	+6·53	9·56	46·9	2·64
5	222·39	0·14	−6·12	+5·86	8·48	46·2	8·70
6	234·62	0·12	−4·85	+4·81	6·83	45·2	14·34
7	246·85	0·09	−3·22	+3·41	4·69	43·4	19·12
8	259·09	0·06	−1·36	+1·75	2·22	37·9	22·62
9	271·32	0·04	+0·62	−0·04	0·62	266·3	24·57
10	283·56	0·02	+2·57	−1·83	3·16	234·5	24·86
11	295·80	0·00	+4·33	−3·47	5·55	231·3	23·51
12	308·02	+0·03	+5·81	−4·85	7·57	230·1	20·70
13	320·25	0·05	+6·90	−5·88	9·06	229·6	16·67
14	332·46	0·08	+7·57	−6·54	10·00	229·2	11·74
15	344·67	0·10	+7·81	−6·81	10·37	228·9	6·26
16	356·88	0·13	+7·64	−6·73	10·19	228·6	0·57
17	9·07	0·16	+7·11	−6·32	9·51	228·4	354·98
18	21·26	+0·19	+6·28	−5·63	8·44	228·1	349·78

Greenwich Midnight.	Selenographical Colong. of the Sun.	Selenographical Lat. of the Sun.	Geocentric Libration Sel. Long. of the Earth.	Geocentric Libration Lat. of the Earth.	Combined Amount.	Direction.	C.
1904.	°	°	°	°	°	°	°
Sept. 19	33·45	+0·22	+5·21	−4·69	7·01	228·0	345·16
20	45·63	0·25	+3·97	−3·56	5·33	228·1	341·30
21	57·81	0·28	+2·62	−2·29	3·48	228·8	338·31
22	69·98	0·31	+1·21	−0·92	1·52	232·8	336·26
23	82·15	0·34	−0·20	+0·48	0·52	22·6	335·21
24	94·32	0·37	−1·57	+1·87	2·44	40·0	335·17
25	106·49	0·40	−2·87	+3·18	4·28	42·1	336·13
26	118·66	0·43	−4·03	+4·36	5·93	42·7	338·12
27	130·83	0·46	−5·05	+5·36	7·37	43·3	341·10
28	143·01	0·48	−5·87	+6·13	8·49	43·8	344·98
29	155·18	0·51	−6·46	+6·62	9·25	44·3	349·70
30	167·36	0·54	−6·79	+6·79	9·60	45·0	355·08
Oct. 1	179·55	0·56	−6·82	+6·61	9·50	45·9	0·87
2	191·74	0·59	−6·51	+6·07	8·90	47·0	6·78
3	203·94	0·61	−5·86	+5·17	7·81	48·6	12·42
4	216·14	0·63	−4·86	+3·94	6·25	51·0	17·39
5	228·35	0·66	−3·52	+2·42	4·27	55·5	21·32
6	240·57	0·68	−1·91	+0·72	2·03	70·2	23·90
7	252·79	0·70	−0·11	−1·06	1·07	174·1	24·92
8	265·01	0·72	+1·75	−2·76	3·27	212·4	24·30
9	277·23	0·74	+3·55	−4·26	5·54	219·8	22·09
10	289·45	0·76	+5·12	−5·46	7·49	223·2	18·48
11	301·67	0·78	+6·36	−6·27	8·93	225·4	13·75
12	313·88	0·80	+7·18	−6·68	9·80	227·1	8·28
13	326·08	0·83	+7·55	−6·71	10·09	228·4	2·45
14	338·28	0·85	+7·45	−6·38	9·81	229·4	356·65
15	350·47	0·87	+6·95	−5·74	9·02	230·4	351·21
16	2·65	0·90	+6·09	−4·85	7·78	231·5	346·35
17	14·83	0·92	+4·97	−3·77	6·24	232·8	342·24
18	27·00	0·95	+3·66	−2·53	4·45	235·3	339·01
19	39·17	0·97	+2·25	−1·20	2·55	241·9	336·72
20	51·33	0·99	+0·83	+0·18	0·85	282·2	335·40
21	63·49	1·02	−0·55	+1·56	1·65	19·4	335·08
22	75·64	1·04	−1·83	+2·88	3·41	32·4	335·79
23	87·80	1·07	−2·95	+4·08	5·04	35·9	337·52
24	99·95	1·09	−3·90	+5·10	6·42	37·4	340·28
25	112·10	1·11	−4·65	+5·91	7·52	38·2	343·99
26	124·25	+1·13	−5·19	+6·44	8·27	38·9	348·57

Greenwich Midnight.	Selenographical Colong.	Lat. of the Sun.	Geocentric Libration Sel. Long. of the Earth.	Lat.	Combined Amount.	Direction.	C.
1904.	°	°	°	°	°	°	°
Oct. 27	136·41	+1·15	−5·52	+6·65	8·64	39·7	353·83
28	148·56	1·17	−5·64	+6·53	8·63	40·8	359·54
29	160·72	1·19	−5·55	+6·06	8·22	42·5	5·40
30	172·89	1·20	−5·25	+5·25	7·42	45·0	11·04
31	185·06	1·22	−4·71	+4·13	6·27	48·7	16·09
Nov. 1	197·24	1·23	−3·94	+2·74	4·80	55·2	20·24
2	209·43	1·25	−2·92	+1·17	3·15	68·2	23·18
3	221·62	1·26	−1·68	−0·51	1·76	106·9	24·73
4	233·82	1·27	−0·26	−2·17	2·19	173·2	24·75
5	246·02	1·28	+1·28	−3·70	3·92	199·1	23·22
6	258·23	1·29	+2·83	−4·97	5·72	209·7	20·22
7	270·43	1·31	+4·25	−5·91	7·28	215·7	15·94
8	282·64	1·32	+5·42	−6·45	8·42	220·0	10·68
9	294·83	1·33	+6·24	−6·59	9·07	223·4	4·84
10	307·03	1·34	+6·64	−6·36	9·20	226·2	358·84
11	319·22	1·36	+6·60	−5·79	8·78	228·7	353·10
12	331·41	1·37	+6·13	−4·95	7·88	231·1	347·89
13	343·59	1·38	+5·30	−3·89	6·58	233·7	343·48
14	355·76	1·40	+4·18	−2·68	4·97	237·3	339·90
15	7·93	1·41	+2·87	−1·38	3·18	244·3	337·31
16	20·09	1·42	+1·46	−0·02	1·46	269·2	335·69
17	32·25	1·44	+0·04	+1·33	1·33	358·3	335·08
18	44·40	1·45	−1·29	+2·64	2·94	26·0	335·49
19	56·55	1·46	−2·47	+3·84	4·57	32·8	336·91
20	68·69	1·47	−3·43	+4·88	5·97	35·2	339·36
21	80·82	1·48	−4·13	+5·71	7·05	35·9	342·82
22	92·96	1·49	−4·58	+6·27	7·76	36·1	347·21
23	105·09	1·50	−4·76	+6·53	8·08	36·1	352·39
24	117·23	1·51	−4·72	+6·44	7·98	36·2	358·12
25	129·36	1·51	−4·48	+6·01	7·50	36·7	4·06
26	141·51	1·51	−4·09	+5·23	6·64	38·0	9·85
27	153·65	1·51	−3·57	+4·14	5·47	40·8	15·07
28	165·80	1·51	−2·94	+2·80	4·06	46·4	19·41
29	177·96	1·52	−2·21	+1·28	2·55	59·9	22·60
30	190·12	1·51	−1·37	−0·32	1·41	103·1	24·46
Dec. 1	202·29	1·51	−0·42	−1·92	1·97	167·7	24·89
2	214·47	1·51	+0·62	−3·41	3·47	190·3	23·88
3	226·65	+1·51	+1·74	−4·69	5·01	200·3	21·44

Greenwich Midnight.	Selenographical Colong. of the Sun.	Selenographical Lat. of the Sun.	Geocentric Libration Sel. Long. of the Earth.	Geocentric Libration Lat. of the Earth.	Combined Amount.	Direction.	C.
1904.	°	°	°	°	°	°	°
Dec. 4	238·84	+1·51	+2·85	−5·67	6·35	206·7	17·70
5	251·03	1·51	+3·89	−6·29	7·39	211·7	12·86
6	263·22	1·51	+4·75	−6·52	8·07	216·1	7·26
7	275·42	1·51	+5·33	−6·37	8·30	219·9	1·27
8	287·61	1·51	+5·59	−5·87	8·11	223·6	355·32
9	299·80	1·51	+5·46	−5·07	7·45	227·1	349·79
10	311·98	1·51	+4·96	−4·04	6·40	230·8	344·97
11	324·16	1·51	+4·13	−2·83	5·01	235·6	341·02
12	336·33	1·51	+3·02	−1·52	3·38	243·3	338·07
13	348·50	1·51	+1·71	−0·17	1·72	264·3	336·11
14	0·65	1·51	+0·30	+1·19	1·23	345·9	335·17
15	12·82	1·50	−1·10	+2·49	2·72	23·8	335·24
16	24·97	1·50	−2·41	+3·70	4·42	33·1	336·32
17	37·12	1·50	−3·53	+4·75	5·92	36·6	338·42
18	49·26	1·49	−4·39	+5·61	7·12	38·0	341·51
19	61·39	1·49	−4·93	+6·22	7·94	38·4	345·59
20	73·52	1·48	−5·14	+6·53	8·31	38·2	350·53
21	85·65	1·47	−5·01	+6·49	8·20	37·7	356·16
22	97·78	1·46	−4·59	+6·10	7·64	37·0	2·19
23	109·90	1·45	−3·93	+5·34	6·63	36·4	8·20
24	122·03	1·44	−3·10	+4·25	5·26	36·1	13·76
25	134·16	1·43	−2·19	+2·90	3·64	37·1	18·47
26	146·30	1·41	−1·23	+1·36	1·83	42·1	22·00
27	158·44	1·40	−0·29	−0·27	0·40	133·0	24·18
28	170·58	1·38	+0·63	−1·87	1·97	198·6	24·92
29	182·74	1·37	+1·51	−3·36	3·68	204·2	24·22
30	194 90	1·35	+2·35	−4·64	5·20	206·9	22·14
31	207·07	+1·34	+3·13	−5·64	6·45	209·0	18·80

The longitudes are reckoned in the plane of the Moon's equator, the axis of reference being the radius which passes through the mean centre of the visible disc. The axis therefore rotates with the Moon, and is not fixed in space.

The inclination of the Moon's equator to the ecliptic is taken as 1°·523, the value used in the *Nautical Almanac* from 1903.

The physical librations in longitude and latitude, as given by Professor Franz's formulæ, have been applied; their values are taken from the *Berliner Jahrbuch* for the days given there, and interpolated by a graphical method for the other days. But the

signs in the *Jahrbuch* require to be reversed in order to reduce to the system used here.

The colongitude of the Sun is 90° (or 450°) *minus* his selenographical longitude. It also is the selenographical longitude of the morning terminator reckoned eastward from the mean centre of the disc. Hence its value is approximately 270°, 0°, 90°, 180° at new Moon, first quarter, full Moon, last quarter respectiveiy. The longitude of the evening terminator is of course 180° greater or less than that of the morning one.

When the geocentric libration in longitude is positive, the region brought into view is on the west limb ; when negative, on the east.

When the geocentric libration in latitude is positive, the region brought into view is at the Moon's north pole ; when negative, at the south.

The column "Combined Amount" gives the distance between the apparent and mean centres of the disc, and the column "Direction" gives the position-angle of the apparent centre from the mean centre, or, which is the same thing, the position-angle of the region which is most carried into view by libration. The angles are reckoned eastward from the northern extremity of the Moon's axis.

The question of discontinuing the columns "Combined Amount" and "Direction" is under consideration. I shall be glad to hear whether any observers make use of them. The information contained in them is of course implicitly the same as in the two preceding columns.

C denotes the geocentric position-angle of the northern extremity of the Moon's axis measured eastward from the northernmost point of the disc. It has been computed by the second formula given in the Preface to the *Nautical Almanac*.

The terms "East" and "West" are used throughout with reference to our sky, and not as they would appear to an observer on the Moon.

I give the method for finding the altitude of the Sun at a given point on the Moon whose position is defined : (1) by selenographical longitude and latitude ; (2) by direction cosines.

In either case the Sun's selenographical colongitude and latitude (K, L supposed) must be found by interpolation from the ephemeris for the given time.

In the first case let the given point be in the position longitude M, latitude N. Longitudes are reckoned from the meridian passing through the main centre of the disc, and the positive direction is that towards Mare Crisium. North latitudes are considered positive.

Then

$$\text{sine Sun's altitude} = \sin \text{L} \sin \text{N} + \cos \text{L} \cos \text{N} \sin (\text{K} + \text{M}).$$

In the second case let ξ, η, ζ be the direction cosines of the given point. The axes are (1) that diameter of the Moon's

equator which is 90° from the main centre of the disc ; (2) the Moon's polar axis ; (3) the diameter through the mean centre of the disc. The positive directions are as above. Mr. Saunder has issued some maps of portions of the Moon's surface from which the coordinates ξ, η, ζ can be taken at sight.

Then the Sun's direction cosines are :

$$\cos \mathrm{K} \cos \mathrm{L}, \sin \mathrm{L}, \sin \mathrm{K} \cos \mathrm{L},$$

and sine Sun's altitude

$$= \xi \cos \mathrm{K} \cos \mathrm{L} + \eta \sin \mathrm{L} + \zeta \sin \mathrm{K} \cos \mathrm{L}.$$

Neither formula is convenient when the Sun's altitude is very great, for an angle near 90° cannot be accurately determined from its sine. However, when the Sun is high the shadows are so inconspicuous that it is not necessary to compute his altitude with great accuracy.

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1903 *September* 19.